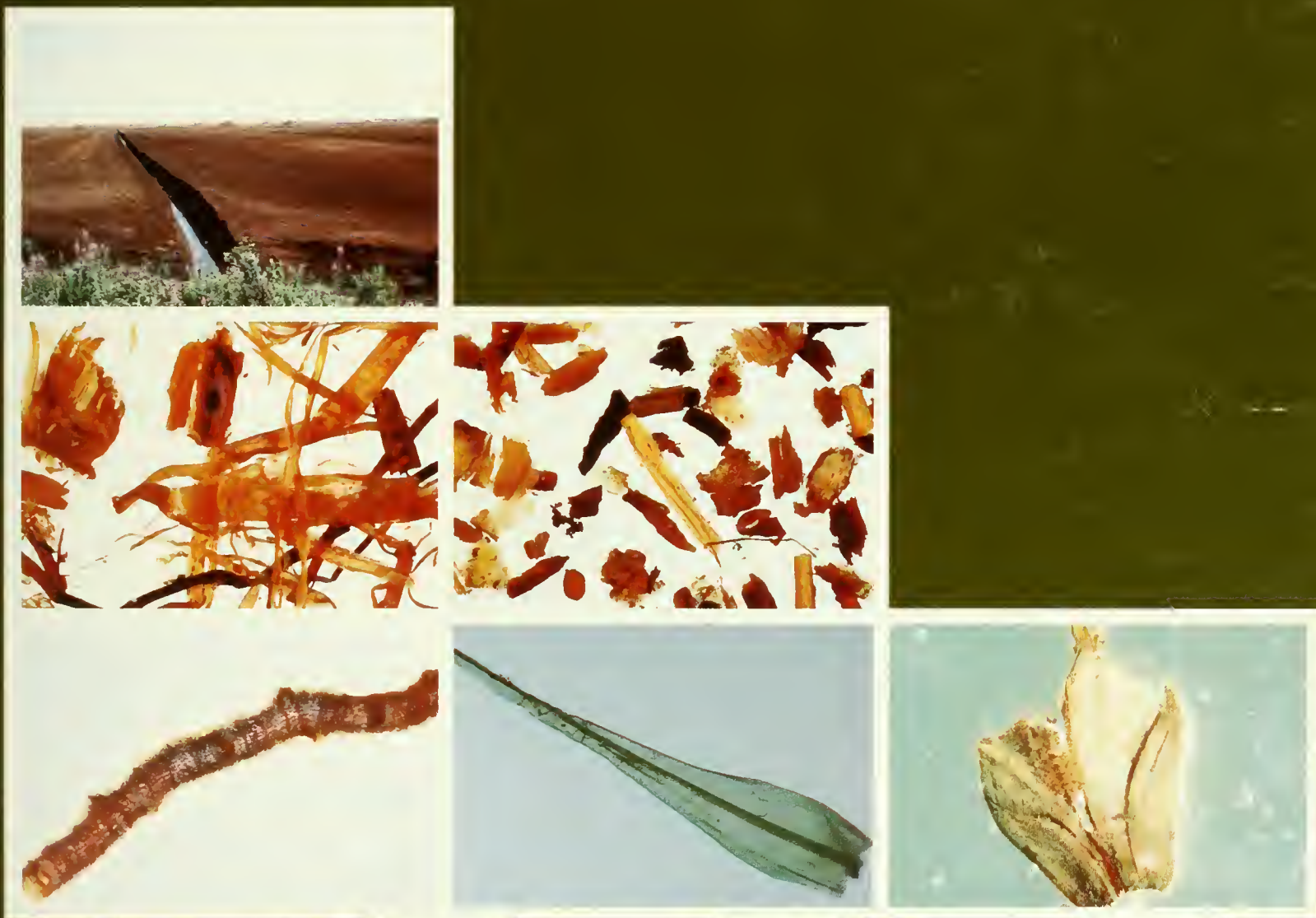





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Guide to the identification of plant macrofossils in Canadian peatlands





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Guide to the identification of plant macrofossils in Canadian peatlands

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INTRODUCTION

In 1974, when the Land Resource Research Centre (Centre de recherche sur les terres) initiated its study of peats and peat soils, the level of knowledge in this field was sparse. There was no basic reference work and no identification guide to support any efforts at characterization of peat soils or to permit the identification of macrofossils or peat materials. Then, as now, except for the publications by Grosse-Brauckmann (1972, 1974, and 1976) there was a scarcity of work devoted to the identification of plant macrofossils in peat.

The elements of the present report were compiled over the years as our own paleobotanical, ecological, and pedological research on peatlands progressed. We are pleased to share the fruits of our labors with others associated, whether closely or remotely, with peat exploitation who feel the need for reference work for use in identifying and differentiating peat materials.

The objective behind the preparation and publication of this guide was to assist prospectors, pedologists, and other potential users in identifying the plant remains and peat materials commonly encountered in Canadian peatlands. The guide lists the most representative peat materials found during the exploration of more than 50 organic deposits in Canada, particularly in eastern Canada, as well as macrofossil analyses for some 30 deposits. In order to facilitate the identification and the registration of differentiating features, the macrofossil assemblages are grouped in terms of their initial association. The elements of fresh plant materials have also been added in order to ensure an improved botanical coverage and a more precise identification of the macroremains.

The macrofossils are treated individually for identification purposes. They are then replaced in their respective natural assemblages in order to maintain the botanical and ecological relationships useful in the establishment of the principal types of peat and peat materials.

The photographs of the macrofossils and the reference elements, accompanied by their identification, form the essential features of the guide. The glossary ensures a better understanding of the terminology used, as well as a precise and more appropriate utilization of the descriptions

and distinctive characteristics of the plant macroremains.

The identification keys are intended to facilitate the identification procedure. They are based on the nature and morphology of the fragments encountered and, when used in the context of our work, should prove to be very effective tools. We hope that the users of the keys will be able to contribute to their further improvement.

The plants whose remains make up peat have been subjected to the effects of time and environmental factors while undergoing the process of fossilization. Thus, the peaty mass we see today is composed of elements that are more or less decomposed, modified, or transformed. A certain amount of segregation has taken place, and as a result, the elements encountered today represent the most resistant. The distinctive properties used to identify the plant macrofossils should, therefore, have sufficient resistance to persist for long periods of time. Although segregation of the materials introduces a slight deformation to the botanical component, this does not affect the exercise because the stated objectives are to identify and differentiate the different types of peat materials. It would be another matter if our aim was to reconstruct the "parent" vegetation and its evolution in a particular ecological context.

The level of identification of plant macrofossils remains dependent on the conditions imposed by the type of analysis possible in the field and on the means available to the prospector. The equipment generally used by a prospector consists of an ordinary hand lens (4 – 20X), and the work is usually done in unfavorable lighting conditions. Water-washing of the materials on a 150-µm sieve results in a more revealing examination. It is still possible to confirm or reject an initial identification by conducting a laboratory verification, using a binocular microscope at higher magnification.

The guide lists 390 plant specimens, that is, 240 macrofossil elements and 150 reference elements. These elements are grouped under 22 families (40 genera), and are subdivided into the following four groups:

- Lignosae – four families (13 genera)
- Herbaceae – five families (12 genera)
- Muscinae – nine families (nine genera)
- Pteridophytae – four families (six genera)

MATERIAL AND METHODS

Choice of materials

The macrofossils inventoried or used here are linked to 15 types of assemblages. The understanding we have acquired concerning peat materials, their principal composition, their distribution, and their relative contribution to the overall peat mass is the result of investigations conducted on more than 50 deposits located in the temperate zone of Canada, and of macrofossil analyses of materials taken from approximately 30 of these deposits. The materials sampled, which enabled us to identify 15 typical macrofossil assemblages, were taken from seven different deposits (Table 1) and covered six different types of peat landform. The desire to avoid repetition of the same types of macrofossils and to keep them within their natural assemblages was the prime motive behind our choice. Due to the insights we acquired in the field, and from the investigations of other authors, the 22 families (40 genera) of plants listed in this guide are in accordance with the botanical profile of the vast majority of the peatlands of the temperate zone of Canada.

The peat material was wet-sieved in order to separate macrofossils larger than 0.450 mm that could be identified at a magnification of less than 20X, according to the procedure described by Diné and Lévesque (1976). This sieving step

permitted us to remove the very fine particulates, as well as the decomposition products encrusting the surface of the macrofossils. It also enabled us to inventory the macrofossils in terms of their size, which greatly improved the quantitative information obtained.

Organs of living plants were added to the macrofossil collection to expand the botanical coverage of this report. The additions comprise species which could be or have been found at one time or another in peat materials sampled by us.

Preparation of reference materials

The reference materials were collected during visits to various peat deposits in eastern Canada. The specimens were washed in water and cleaned of all materials that might obscure the distinctive morphological elements. They were then preserved in a solution of formaldehyde, acetic acid, and ethanol (Johansen 1968). The specimens were lightly stained with a solution of methyl blue in order to give contrast to morphological elements that would otherwise have been difficult to see. The treatment with methyl blue also proved useful in the identification of certain fossilized Muscinae leaves.

Table 1. Provenance of typical macrofossil assemblages

Typical macrofossil assemblages	Peat landform	Site	Coordinates
Lignosae-Herbacae Lignosae-Herbacae-Pteridophytae Herbacae-Muscinae (SH + DP) Herbacae-Lignosae (LA)	Deltaic marsh	Keswick, Ont.	79°31' long. W 44°12' lat. N
Herbacae-Muscinae Pteridophytae-Lignosae-Herbacae	Basin swamp	Alfred, Ont.	74°49' long. W 45°28' lat. N
Herbacae-Muscinae-Lignosae Muscinae-Herbacae	Basin swamp	Albion Road, Ont.	75°37' long. W 45°18' lat. N
Muscinae	Dome bog	St. Charles, N.B.	64°57' long. W 46°38' lat. N
Herbacae Herbacae-Lignosae	Coastal high marsh	St. Andrew, P.E.I.	62°50' long. W 46°22' lat. N
Lignosae-Herbacae-Muscinae Lignosae-Muscinae-Herbacae	Basin bog	Gable Head, P.E.I.	63°33' long. W 46°26' lat. N
Muscinae-Lignosae Muscinae-Herbacae-Lignosae	Raised bog	Black Banks, P.E.I.	64°00' long. W 46°44' lat. N

Macrofossil inventory procedure

The methodology used in the inventory of the macrofossils may be divided into two steps. First, the botanical identification of the fragment was made, followed by the quantitative evaluation of the different botanical components that defined the macrofossil assemblage. In our study, however, identification and the quantitative evaluation were done at the same time.

Qualitative analysis of macrofossils

The foregoing system enabled us to identify macrofossils specimen by specimen. It also made it possible to take into account the origin and the botanical nature of the macroremains as well as the degree of expertise of the analyst. All the macroremains inventoried are identified by an alphabetic code composed of two letters to indicate the origin and the botanical nature of each fossil; the code is used to identify the botanical components (B.C.) during the counting (Fig. 1). Lists I, II, III, and IV were established for this purpose. They are not exhaustive, and their contents can be shortened, added to, or adjusted, according to usage.

Site: _____ Date: _____
 Depth: _____ Analyst: _____
 Granulometric fractions: _____ Comments: _____
 Magnification: _____

Botanical component (B.C.)	Field of vision												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
Lignosae													
Herbaceae													
Muscinae													
Pteridophytae													
ALTER													

Fig. 1. Tally sheet

The four levels of differentiation used in this system (Table 2) have the advantage of providing an identification of the macrofossils. In this way, the first level, being of an inclusive nature, allows the identification of a macrofossil as belonging to

the Lignosae, Herbaceae, Muscinae, or Pteridophytae group. The other levels of differentiation, however, assign to a macrofossil an identification that is progressively more refined and exclusive, and they demand a higher degree of expertise regarding the organs and tissues of peatland plants.

Table 2. Levels of differentiation of the botanical origin of macrofossils

Level 1	Level 2	Level 3	Level 4
Groups	Families	Genera	Species
Lignosae (LI)			
Herbaceae (HE)			
Pteridophytae (PT)			
Muscinae (MU)			
ALTER (AL)			

This way of differentiating the botanical origin of the plant macrofossils and the macrofossil assemblages has led to the creation of several terms that allow the systematic grouping of certain families within the context of contemporary plants. The first level of differentiation is divided into four groups (Lignosae, Herbaceae, Pteridophytae, and Muscinae) that correspond to the dominant plant groups encountered in the various peat materials. Next, the assignment is progressively made to families, then to genera, and then to species. As a result of this process, the Lignosae group contains all the arborescent and shrubby vegetation; the Herbaceae group encompasses all the herbaceous families (Cyperaceae, Gramineae, Juncaceae); the Pteridophytae group is used in instances where the macrofossils to be identified may belong to the Equisetaceae, the Osmondaceae, or the Polypodiaceae; and the Muscinae group is used for macrofossils that may belong to all the vegetal families contained in the Bryophyta division.

Quantitative analysis of macrofossils and definition of assemblages

The counting of a minimum of 500 macrofossils is done on each of the three granulometric fractions retained after the wet-sieving of 30 g of peat material. The counting of all the material in these fractions is virtually impossible, so a subsample is taken containing a minimum of 500 specimen fragments, which are then spread out on a microscopic slide provided with a grid. Particular attention is given to the proper spreading of the specimens on the slide in order to avoid overlapping. Each of the fields of vision were counted, using a binocular microscope, until the minimum number of individual specimens is

obtained. In general, 10 or 12 fields of vision are necessary in order to obtain a count of 500 specimens (Dinel et al. 1983).

After the counting of each of the three granulometric fractions is completed, this information is grouped in a summary data sheet (Fig. 2), which allows us to define the macrofossil assemblage being studied. According to the objectives of the study, it is possible to obtain more or less detailed information on the origin and botanical nature of the macrofossils, and on the relative frequency of occurrence of each of these fossils, in accordance with the degree of expertise of the analyst.

This method is very effective for differentiating peat materials in terms of their botanical origin while keeping the dimensions of the macrofossil in mind. In practice, the analyst would have a tendency to overestimate the importance of the larger specimens at the expense of the smaller ones. However, in paleoecological studies, this method allows us to collect more information on the total population of macrofossils, and makes it possible to obtain an improved interpretation (Dinel 1984).

Site: _____ Date: _____
 Depth: _____ Analyst: _____
 Comments: _____ Macrofossil assemblage: _____
 Magnification: _____

Botanical component (B.C.)	Granulometric fractions			Sub-total	Proportion (%) of the assemblage
	≥ 2.00 mm	1.00-2.00 mm	0.45-1.00 mm		
Lignosae					
Herbaceae					
Muscinae					
Pteridophytae					
ALTER					

Fig. 2. Summary sheet

List I. List of organs, tissues, and their codes

English	French	Latin	Code
branch	branche	ramus	Rm
branchlet	rameau	ramellus	Re
bract	bractée	—	Br
bud	bourgeon	gemma	Ge
bud scale	écaille de bourgeon	—	Eb
capsule	capsule	—	Ca
collenchyma	collenchyme	collenchyma	Cl
cone scale	écaille de cones	—	Ec
cortex	écorce	cortex	Co
crown	collet	—	Cf
epidermis	épiderme	liber	Li
fruit	fruit	fructus	Fr
leaf	feuille	folium	Fo
leafy stem	tige feuillée	stipes-folium	Sf
mesoblast	mésoblaste	—	Me
needle	aiguille	acus	Ac
node	noeud	nodus	No
residual tissues	reste tissulaire	—	Rt
rhizome	rhizome	rhiza	Rh
rhizome scale	écaille de rhizome	—	Er
root	racine	radix	Ra
runner	stolon	—	Sn
sclerenchyma	sclérenchyme	sclerenchyma	Sc
seed	graine	granum	Gr
sporangium	sporange	sporangium	Sp
stem	tige	stipes	St
strobile	strobile	strobilus	Sr
vascular bundle	nervure	nervus	Ne
xylem	xylème	—	Xy

List II. List of families and their codes

Aceraceae	AC	Grimmiaceae	GI
Amblystegiaceae	AM	Gramineae	GR
Aquifoliaceae	AQ	Hypnaceae	HY
Araliaceae	AR	Hypericaceae	HE
Aulacomniaceae	AU	Joncaceae	JN
Betulaceae	BE	Joncaginaceae	JO
Brachytheciaceae	BR	Labiataeae	LB
Bryaceae	BY	Lycopodiaceae	LY
Capriofoiaceae	CA	Myricaceae	MY
Climaciaceae	CL	Osmondaceae	OS
*Conifer	CO	Pinaceae	PI
Cupressaceae	CU	Polypodiaceae	PO
Cyperaceae	CY	Polytrichaceae	PL
Dicranaceae	DI	Primulaceae	PM
Empetraceae	EM	Salicaceae	SA
Equisetaceae	EQ	Selaginellaceae	SE
Ericaceae	ER	Sphagnaceae	SH
Gentianaceae	GN	Umbelliferaceae	UM

* Other taxonomic unit

List III. List of genera and their codes

<i>Abies</i>	AB	<i>Lycopus</i>	LO
<i>Acer</i>	AC	<i>Lysimachia</i>	LS
<i>Alnus</i>	AL	<i>Menyanthes</i>	ME
<i>Amblystegium</i>	AY	<i>Myrica</i>	MR
<i>Andromeda</i>	AN	<i>Mnium</i>	MN
<i>Aralia</i>	AA	<i>Nemopanthus</i>	NE
<i>Aronia</i>	AR	<i>Onoclea</i>	ON
<i>Aulacomnium</i>	AO	<i>Osmunda</i>	OM
<i>Betula</i>	BT	<i>Phragmites</i>	PH
<i>Calamagrostis</i>	CM	<i>Picea</i>	PE
<i>Calliergon</i>	CG	<i>Pinus</i>	PN
<i>Carex</i>	CR	<i>Pleurozium</i>	PR
<i>Chamaedaphne</i>	CS	<i>Pohlia</i>	PB
<i>Cladium</i>	CD	<i>Populus</i>	PP
<i>Climacium</i>	CI	<i>Potentilla</i>	PJ
<i>Dicranum</i>	DC	<i>Polypodium</i>	PY
<i>Drepanocladus</i>	DP	<i>Polytrichum</i>	PC
<i>Dryopteris</i>	DR	<i>Pteridium</i>	PT
<i>Dulichium</i>	DU	<i>Ptilium</i>	PU
<i>Elocharis</i>	EL	<i>Rhacomitrium</i>	RO
<i>Empetrum</i>	EP	<i>Rhododendron</i>	RH
<i>Equisetum</i>	EV	<i>Rhynchospora</i>	RY
<i>Eriophorum</i>	EI	<i>Salix</i>	SL
<i>Gaylussacia</i>	GA	<i>Scheuchzeria</i>	SZ
<i>Glyceria</i>	GL	<i>Scirpus</i>	SC
<i>Hylocomium</i>	HL	<i>Spartina</i>	SP
<i>Hypericum</i>	HA	<i>Sphagnum</i>	SH
<i>Hypnum</i>	HP	<i>Thuja</i>	TH
<i>Juncus</i>	JU	<i>Triglochin</i>	TR
<i>Kalmia</i>	KA	<i>Typha</i>	TP
<i>Larix</i>	LA	<i>Vaccinium</i>	VA
<i>Ledum</i>	LE	<i>Viburnum</i>	VI
<i>Lycopodium</i>	LC	<i>Viola</i>	VO

List IV. List of secondary components (ALTER)

Acarians	ACAR
Aggregate of fine roots of Herbaceae	AGHE
Aggregate of fine materials	AGAM
Calcarius (calcareous)	CALC
Cenococcum	CENO
Charcoal	CHAR
Faecis (fecal pellets)	FEPE
Gastropoda (one valve)	GAST
Helicoids	HELI
Mycorrhizae	MUCO
Mycorrhizae ectotrophic	MYEC

GLOSSARY

aculeate

Having very small prickles.



acuminate

Tapering to the apex; sides more or less pinched in before the tip.



alar cell

Differentiated cell at the base of the leaf.



alveolate

Having the appearance of a honeycomb.

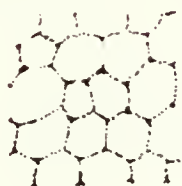


anasomosis

Ornamentation on the surface of the bark or the tegument of seeds, composed of elongate rope-like ridges, many of which cross or touch one another (e.g., the bark surface of *Chamaedaphne calyculata* older than 2 years).

areolate

Having small spaces between the leaf veins.



asymmetric

Not symmetrical.



barbellate

Having short, stiff, hooked hairs or bristles.



canescent

Having a fine, grayish white pubescence.



carebate

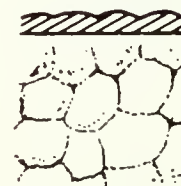
Longitudinal protrusion, or keel, along the back of an organ (e.g., a leaf).

collenchyma (pl. collenchymata)

A support tissue composed of living cells more or less elongate, equipped with an irregularly lignified primary wall (Pl. 31-9).

colliculate

Having small elevations.



conduplicate

The V-shaped cross section common to certain linear leaves (needles), e.g., the leaf of *Juniper communis*.

cordate

Heart-shaped.

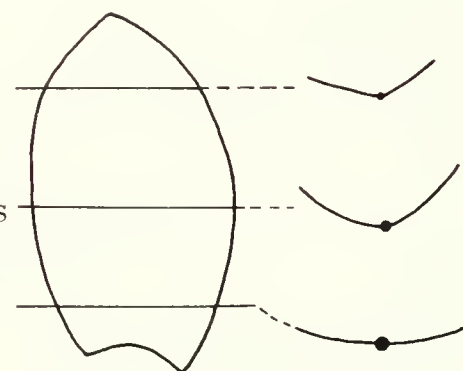


costa (pl. costae)

Leaf vascular bundle associated with the Muscinae.

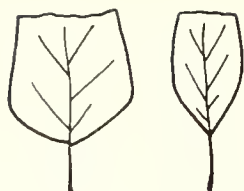
cucullate

Hood-shaped; having basal edges rolled inward.



cuneate

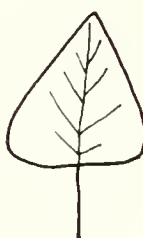
Narrowly triangular with acute angle toward base; wedge-shaped.

**cuspidate**

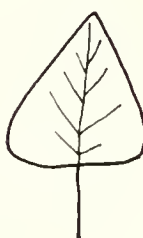
Abrupt, short, sharp, firm point at the apex.

**cymbifoliate**

Having the form of a gondola or boat.

**deltoid**

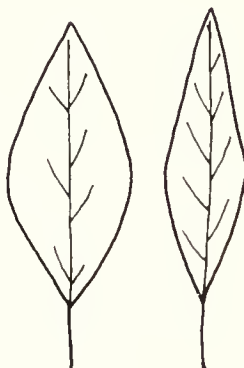
Triangular.

**dentate**

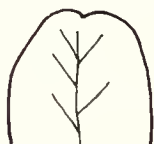
Toothed, directed outward.

**elliptic**

Shaped like an ellipse; widest in centre and two ends equal.

**emarginate**

Having a shallow marginal notch.

**entire**

Having the margin continuous, or not divided by teeth or serrations.

**ephippium (pl. ephippia)**

Protective capsule covering the fertilized ovum of Cladocera (crustaceans) (Pl.31-3).

**falcate**

Scythe- or sickle-shaped.

fasicle

Bundle of leafy branches joined at a point on the stem of *Sphagnum* sp. (Pl.30-12).

flabelliform

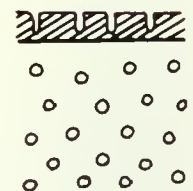
Flabellate, shaped like a fan.

flexuous

Bent or curved in varying directions.

foveate

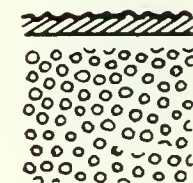
Pitted.

**glochidiate**

Having barbed tips.

**granulate**

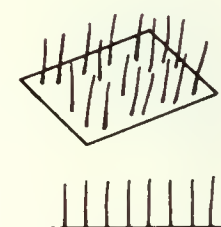
Granulated.

**hilum**

Scar left on the tegument of the seed after the detachment of the funiculus.

hirsute

Having moderately coarse, stiff hairs.



hydathode

Structure, modified from leaf conductive tissue, that allows the exudation of water through a pore (*Scheuchzeria palustris*) (Pl.9-9).

hydrocyte

A cell that covers the stem of *Sphagnum* sp., and which permits the retention of a large amount of water (Pl.31-1).

insect elytra

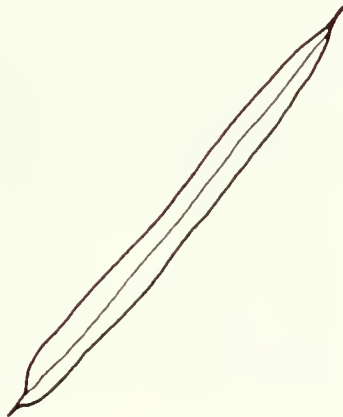
Chitinous, leathery outer wing parts that cover and protect the flight wings of Coleoptera (beetles) (Pls. 14-10 and 17-9).

lanceolate

Tapering to a point at apex; several times longer than wide.

**linear**

Leaf narrow and flat with sides parallel.

**lineate**

Marked with lines or stripes.

**lineolate**

Marked with fine lines.

**mesoblast**

A short stem from which emerge the needles in *Larix laricina* (Pls. 16-11 and 20-12).

mucronate

A short, small, abrupt tooth-like tip at the apex.

**mycorrhiza (pl. mycorrhizae)**

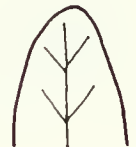
Fungi living in association with roots of certain plant species.

obovate

More or less ovate with basal end narrower.

**obtuse**

Blunt at the apex.

**oogonium (pl. oogoniums)**

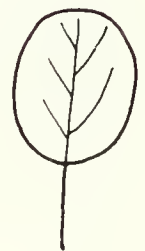
Organ where the female cells are formed in the Thallophytes (Pl.31-4), e.g., Characeae.

operculum (pl. opercula)

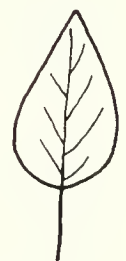
Lid covering the mouth of a moss capsule.

oval

Broadly elliptic.

**ovate**

Having an outline similar to longitudinal section of an egg; oval-shaped.



peltate

Having the stem or support attached to the lower surface instead of at the margin or base; umbrellalike.

**perigynium (pl. perigynia)**

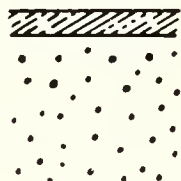
Fruit envelope of the *Carex* group (Pl.19-9).

pubescent

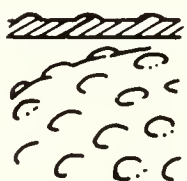
Covered with fine, soft hairs, or downy.

**punctate**

Dotted with depressions or minute spots.

**pustulate**

Covered with pustules; pimple-like elevated area covering surface tissues.

**rachis**

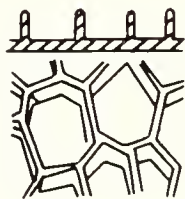
Part of a plant bearing the folicles (leaflets) in the fern group (Pls.31-1 and 30-3).

ramate

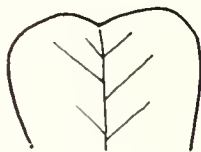
Related to branch leaf.

reticulate

Having veins or lines that form a network.

**retuse**

Having the apex rounded or obtuse with a slight notch.

**revolute**

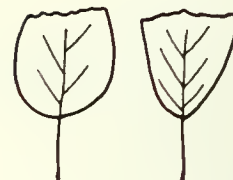
Property of leaves whereby the edges are partially curled downward, e.g., leaf of *Ledum groenlandicum*.

ribbed

Having marks like a rib; ridged.

**rounded-obtuse**

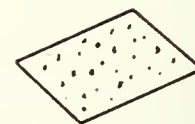
Circular; not pointed or acute.

**rugose**

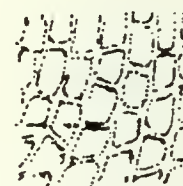
Wrinkled.

**scabrous**

Rough to the touch; prickly.

**scalariform**

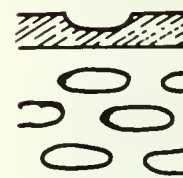
Having transverse bars.

**sclerotium (pl. sclerotia)**

Asexual mass of fungal mycelia.

scrobiculate

Having numerous shallow grooves.

**semicircular**

Half-mooned outline of the transverse cross section of leaves, e.g., leaf of *Pinus banksiana*.

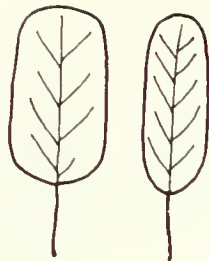
serrate

Saw-toothed, directed forward.



spatulate

Broad and rounded at apex and tapering at base; shaped like a flattened spoon.

**sporangium (pl. sporangia)**

Spore sac of a capsule.

statoblast

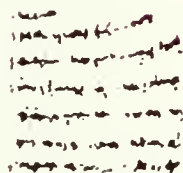
Discoid capsule covered by a chitinous membrane, used for asexual reproduction in bryozoans (Pl.31-7).

stipitate

Having or borne on a support, or short stalk.

striate

Marked with parallel lines.

**style**

Upper elongation of the ovary within which the pollenic tube develops.

sulcate

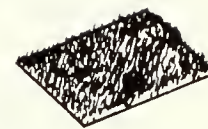
Furrowed, or grooved.

**tegument**

Seed case, or envelope.

tomentose

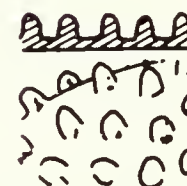
Covered with densely matted hairs.

**truncate**

Base or apex transversely straight or nearly so, as if cut.

**tuberculate**

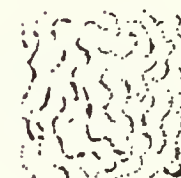
Having small nodules.

**uncinate**

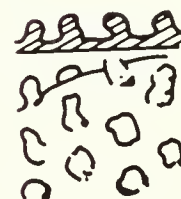
Bent at the apex like a hook.

**undulate**

Having a wavy surface.

**verrucose**

Warty.



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IDENTIFICATION KEYS TO PLANT MACROFOSSILS IN PEATS

The following identification keys have been developed on the basis of the morphology and nature of specimens encountered in the various peatlands studied. More than 100 taxa divided among 26 specimen types have been listed

The purpose of the keys is to describe briefly the botanical nature and origin of a specimen. Starting from a general key, the user can determine the specific key corresponding to the organic nature of the specimen to be identified. Afterward, within each key, it is then possible to establish a code composed of numbers which refer to the persistent descriptive elements of the macrofossil. Under this code, additional morphological elements can be found.

To identify a given specimen the following steps should be taken:

1. Using the general key, establish the specific key corresponding to the nature of the specimen.
2. Determine the code corresponding to the persistent morphological elements (classification criteria) appearing in the specific key.
3. Using the code obtained, refer to the key specific to the code obtained in (2) and follow the key indicators to determine the origin of the specimen.
4. Compare the morphological elements of the specimen to those of the key, making use of the macrophotographs.
5. When the foregoing steps are completed, it is possible that the identification obtained might not be satisfactory or that the user might come to an impasse. It will then be necessary to verify the choice of classification criteria (how the code was obtained). If the same result is obtained a second time, it could indicate that the specimen falls outside our classification criteria.

The following is an example of the steps to follow in identifying a specimen. We wish to identify a specimen that has the following morphological properties: elongate, opaque, original form, dull, cylindrical, and nodulose (Pl. 27-3):

1. General key: Go to (1) because specimen is cylindrical, subelongate; surface is glossy or dull; and nodes are present.
2. Specific key: Obtain a code composed of three numbers.
First number: Tissue type = 2 for ligneous
Second number: Node type = 2 for dot-like
Third number: Surface type = 2 for dull
The code is therefore **222**.
3. In the specific key 1.0, go to 222; examine the following additional morphological properties:

foliar scar, tri-verticillate, and longitudinal groove below the foliar scar.

Our specimen is therefore most likely a stem of *Kalmia angustifolia* (StKA_{an}).

1. General key to plant macrofossils

1. Specimen cylindrical, subelongate, having no bilateral symmetry, and more or less truncated at extremities; surface glossy to dull. Specimens subcircular, with loose tissues, and having one or more nodes. Stems and branches exhibiting foliar nodes or scars. (If they do not, go to 4.) Structure with leaves. (Go to 2.) (Structure includes stems, branches, roots, rachis, and rhizomes.)

Key to elongate structures (p. 17)

2. Specimen flattened, often translucent, having several or no vascular bundles. (If specimen shows bilateral symmetry, it is a leaf; otherwise it is a piece of thin bark.) This definition includes leaves associated or not associated with branches and thin barks.

Key to leaves (p.21)

3. Specimen with outline more or less spherical to cylindrical; surface glossy to dull; usually having bilateral symmetry whose plane passes through the major axis. Length less than 15 mm (includes seeds, terminal buds of mosses, and unopened cones of conifers.)

Key to seeds (p.24)

4. Specimens having other shapes. (These include wood, bud scales, opaque bark, ephippia, epiderma, fruits, hydathodes, mesoblasts, root nodules, oogoniums, opercula, sporangia, and statoblasts.)

Complementary key (p.28)

1. Key to elongate structures

This key was developed according to the type of tissue, node, and surface of the specimen.

1.1 Definition of classification criteria

1.1.1 Tissue type

- (1) Herbaceous: Soft tissue, includes herbaceous plants and mosses, generally flattened in the peat matrix; dark stems of *Sphagnum* sp. fall into this category; for example, fossil stems of *Typha* sp.
- (2) Ligneous: Rigid tissue, generally covered with bark, and retaining its original form in the peat matrix; for example, branchlets of *Picea* sp.

1.1.2 Node type

The definition of node here corresponds to all external structures that give rise to a branch or root. According to the particular specimen, the node can take several forms:

- (1) Annular-circular: Node corresponds to a ring-like feature, more or less broad, circling the elongate structure; for example, rhizome of *Menyanthes trifoliata*.
- (2) Dot-like: Node corresponds to an external mark: aerial buds and foliar scars; for example, branches of *Ledum groenlandicum*.
- (3) Absent: Without node.
- (2) Dull: The rugose surface prevents the reflection of light, for example stem of *Kalmia* sp.
- (3) Verrucose-tuberculate: Surface projections of more or less high relief are visible to the naked eye or by using a hand lens. The projections of the nodes, if they are sufficiently closely spaced, result in a tuberculate surface, for example branchlets of *Picea* sp.

1.1.3 Surface type

Surface type refers to the surficial character of the specimen.

- (1) Glossy: There is no surface sculpture and light is reflected by the surface, for example epidermis of the stem of the Cyperaceae.
- (4) Striate-anastomotic: Small-scale tissue strands cover the surface. These might anastomose one another, for example stem of *Chamaedaphne calyculata* older than 2 years.
- (5) Other.

1.2 Key to specific identification of elongate structures

111

- (a) Structure pale whitish beige. Internodal length rather constant (approximately 2 cm); root insertion points few, adjacent to nodes, and all on the same side. Remains of sheath-forming leaves over the nodes present *Scheuchzeria palustris* (Pls. 32-3, 7-11)
- (aa) Rhizomes of other types Cyperaceae

112

- (a) Diameter, approximately 1 cm; internodal length 1-4 cm; root insertion points scattered over internodal space. Nodes continuous, annular, thin, and well-delineated. Internodal surface generally dull *Menyanthes trifoliata* (Pl. 8-9)
- (aa) Diameter < 0.5 cm b
- (b) Absence of roots in internodal space. Stem pale or dark c
- (bb) Presence of at least one root insertion point d
- (c) Stem dark. Insertion points corresponding to base of leaves. Stem partially scaly *Polytrichum* sp. (Pl. 25-4)
- (cc) Stem pale. Node forming a thick and swollen ring. Surface distinctly striate (collenchyma fibers) *Calamagrostis canadensis*
- (ccc) Internodal surface nonstriated. Node clearly delineated and narrow Gramineae (stem) (Pls. 17-8, 19-2)
- (d) Rhizome short, up to 4 cm. Presence of dot-like and annular nodes, closely spaced (approximately 5 mm). Roots, if present, black *Eriophorum spissum* (Pls. 8-7, 23-2)
- (dd) Rhizome small (diameter 3-5 mm), short or long; internodal spacing small (< 1 cm). Nodes well-defined. Absence of lignified strand-like tissues. If one or more of these characteristics do not apply to the specimen, record "Rhizome of the Herbaceae"; if not Cyperaceae (Pls. 18-10, 18-11, 21-6)

122

- (a) Structure pale, beige. Roots of the order N + 1 grouped and perpendicular to the roots of the order N (rhizome) *Typha* sp. (Pls. 9-5, 8-1)
- (aa) Structure pale, beige. Roots of variable types. Presence of hairs or projections on surface; if not, record "Herbaceae" Cyperaceae (Pls. 17-11, 17-12, 29-8)
- (b) Stem dark, more or less reddish, spongy appearance. Foliar scars alternate, perpendicular, or nearly so, to the stem axis *Sphagnum* sp. (Pls. 14-8, 24-11)
- (bb) Stem dark, variable appearance. Foliar scars often formed of basal remains of leaves. If leaves present, refer to key to leaves; if absent Bryale (Pls. 15-11, 24-1, 24-3, 24-6)

131

- Absence of root or foliar nodes or scars. Surface smooth Herbaceae (stem) (Pl. 14-11)

132

- (a) Structure dark to black b
- (aa) Structure pale, contains at least two central ligneous axes c
- (b) Root network nondendritic, that is, roots of the order $N + 1$ attached in perpendicular fashion to roots of the order N ; roots of the order $N + 2$ rare or nonexistent; root diameter > 1 mm *Osmunda* sp.
- (bb) Roots of the order $N < 1$ mm Filicinae (Pl. 17-2)
- (c) Root network dendritic; no hairs on roots Herbaceae (Pls. 13-7, 9-3)
- (cc) Specimen clearly elongate and smooth. Nodes, if present, point-type, opposed, more or less spaced, and usually circular; single vascular scar Filicinae (rachis) (Pls. 29-5, 30-1, 30-3, 30-6)

212

- Nodes annular, discontinuous, formed of several root-insertion points, internodal spacing approximately 10 cm; rhizome ligneous *Potentilla palustris* (Pl. 5-4)

222

- (a) Foliar scars often tri-verticillate; longitudinal grooves below each scar *Kalmia angustifolia*
- (aa) Other types of scars b
- (b) Structure black, more or less rectilinear, often intermixed with peaty sediments Filicinae (roots) (Pl. 28-12)
- (bb) Presence of foliar scars c
- (c) Twig with small diameter (approximately 3 mm), rectilinear; alternating foliar scars *Vaccinium oxycoccos/V. macrocarpon* (Pl. 2-5)
- (cc) Other different types of twigs d
- (d) Foliar scar clearly raised with respect to plane of branch *Andromeda glaucophylla* (Pl. 1-9)
- (dd) Other types of (scars) e
- (e) Vascular scar, single, linked to bud by miniscule ramp; glabrous branch *Rhododendron canadense*
- (ee) Other types of scars f
- (f) Annual branchlet, pubescent. Plane of foliar scar at same level as that of branchlet *Ledum groenlandicum* (Pl. 2-4)
- (ff) (1) Foliar scars only Lignosae (stem) (Pl. 13-2)
- (2) Root scars only (axis often sinuous and with an asymmetric cross section Lignosae (root) (Pl. 18-12)
- (3) Root and foliar scars Lignosae (underground stem) (Pl. 1-3)

223

- (a) Branchlet, if bark present, verrucose; bud, if present, ornamented on each side by a guard scale, acuminate *Vaccinium angustifolium/V. myrtilloides* (Pl. 2-1)
- (aa) Other types of branchlets b
- (b) Branchlets, clearly tuberculate, each tubercle representing the support site of a needle *Picea mariana* (Pl. 19-11)
- (bb) Branchlet having a few lenticels, and with bud being carried on a projection larger than the bud itself *Nemopanthus mucronata*

224

- (a) Branchlet longitudinally sulcate (sulciform) *Larix laricina*
- (aa) Other types of branchlets b
- (b) Annual branchlet finely pubescent; branchlets > 2 years, striated, anastomotic *Chamaedaphne calyculata* (Pl. 1-8)
- (bb) Branchlet marked otherwise c
- (c) Branchlet with opposing foliar scars *Kalmia polifolia*
- (cc) Annual branchlet with oval lenticels. Vascular scar: three bundles (fascicules), alternating foliar scars *Myrica gale* (Pl. 2-2)

232

- (a) Specimen black on surface, with a pale central axis Filicinae (rhizome) (Pl. 29-4)
- (aa) Specimen not black on surface, more or less elongate Lignosae (Pls. 29-6, 29-11)

233

Branchlet flattened, covered with leaves of two sorts
..... *Thuja occidentalis* (Pls. 4-5, 4-6)

235

Black specimen (diameter 5–10 cm) *Osmunda* sp. (rhizome)

2. Key to leaves

This key is based on the identification of outline type and margin type, the form of the apex and base, and the cross section transverse to the major axis of the leaf.

2.1 Description of the classification criteria

2.1.1 Outline type

- (1) Lanceolate-elliptic: *Sphagnum* sp.
- (2) Oblanceolate: *Myrica gale*
- (3) Linear: *Larix laricina*
- (4) Other

2.1.2 Margin type

- (1) Entire: *Kalmia angustifolia*
- (2) Dentate over entire margin of leaf blade: *Vaccinium angustifolium*
- (3) Dentate only near tip: *Myrica gale*
- (4) Other

2.1.3 Type of apex

- (1) Pointed: *Picea* sp.

- (2) Blunt: *Kalmia* sp.
- (3) Emarginate: *Abies balsamea*
- (4) Acuminate: *Aulacomnium* sp.
- (5) Cuspidate: *Plagiomnium* sp.

2.1.4 Type of base

- (1) Cuneiform-attenuate: *Myrica gale*
- (2) Rounded: *Kalmia* sp., *Chamaedaphne calyculata*
- (3) Truncate: *Dicranum* sp.
- (4) Other

2.1.5 Cross section shape

- (1) Elliptic: *Polytrichum* sp.
- (2) Spatulate-linear: *Osmunda* sp.
- (3) Conduplicate-semicircular: *Pinus banksiana*
- (4) Revolute: *Andromeda glaucophylla*
- (5) Triangular: *Pinus strobus*
- (6) Rectangular: *Picea* sp.

2.2 Key to specific identification of leaves

11114

- (a) Petiole and underside of leaf tomentose-woolly; upper leaf surface colliculate *Ledum groenlandicum* (Pl. 3-3)
- (aa) Tip pointed-acuminate. Abaxial cover composed of straight, short hairs *Andromeda glaucophylla* (Pl. 2-9)

11124

- Petiole curved and offset with respect to the major axis of leaf; length < 1 cm *Vaccinium oxycoccos* (Pl. 3-5)

11133

- (a) Leaf opaque (coniferous), with scale-like form e
- (aa) Leaf translucent (Bryophyte) b
- (b) Costa single, up to two-thirds length of leaf; cell broadly hexagonal *Amblystegium* sp. (Pl. 22-11)
- (bb) Costa of a different type c
- (c) Costa double, terminating before first quarter of leaf; alar cells subcircular, well-differentiated. Leaves strongly cucullate at tip. Stem dark, red; junctions, if present, pinnate *Pleurozium schreberi* (Pls. 15-7, 12-11)
- (cc) Costa absent d
- (d) Branch leaf complex dark brown. Leaves glossy, with cells elongate and sinuous; alar cells showing slight differentiation *Scorpidium* sp. (Pl. 26-1)
- (dd) Leaf cucullate, dull and whitish, detaching easily from the stem; leaf-blade composed of a network of complex cells *Sphagnum* sp. (Pl. 15-1)
- (e) Leaves of two types on branchlet; presence of resiniferous vesicle on underside of leaf; branchlet flattened with an elliptic cross section *Thuja occidentalis* (Pls. 4-5, 4-6)
- (ee) Leaves all the same, possessing dorsal resiniferous vesicle toward base; branch with a circular cross section *Juniperus horizontalis* (Pl. 4-2)

11212

- (a) Leaf length < 6 cm *Kalmia angustifolia* (Pl. 14-3)

11222

- Leaf length < 1.8 cm *Vaccinium macrocarpon* (Pl. 3-7)

11433

- (a) Leaf plane, wrinkled or not, uncarenate, with costa extending beyond the upper half of leaf; branchlet, if present, hooked at tip; leaves more or less falciform
..... *Drepanocladus* sp. (Pls. 21-12, 22-7)
(aa) Leaf more or less revolute. Costa single, well visible, disappearing before reaching the apex. Foliar cells subcircular *Aulacomnium* sp. (Pls. 31-8, 32-5)

12112

- (a) Leaf veins not reaching margin; petiole pubescent; resembling *Vaccinium myrtilloides* *Vaccinium anjustifolium* (Pl. 3-1)
(aa) Veins obscure, petiole glabrous, presence of small dots (peltate), more or less glossy, on the whole leaf surface *Chamaedaphne calyculata* (Pls. 2-7, 4-11)

12222

- Veins parallel and pinnate, terminating at leaf margin; margin crenelate
..... *Osmunda regalis*

13133

- Costa terminating slightly before leaf tip; paraphyllia and propagula present at leaf axes *Climacium* sp. (Pls 11-9, 11-12)

13232

- Costa complete; margin doubly denticulate *Mnium* sp.

13431

- Leaf often attached to stem. When unattached, base of leaf broadened and corresponding to sheath connected to stem. In the fossil state, denticulated portion at tip may be obscure *Polytrichum* sp. (Pls. 25-3, 12-7)

13432

- Costa double and obscure at base of leaf. Several paraphyllia present at base of each branch. Branch leaves wrinkled and falciform; stem leaves larger than those of branch leaves. Branches pinnate *Ptilium crista-castensis* (Pl. 12-4)

13433

- (a) Leaves gently acuminate from base to tip *Dicranum* sp. (Pls. 12-2, 12-3)
(aa) Leaves different from above b
(b) Leaves cucullate and strikingly dentate at tip. Paraphyllia numerous; costa double. Branches 2-3 times pinnate in one plane
..... *Hylocomium splendens* (Pls. 12-5, 12-6)
(bb) Leaves falciform, smooth to weakly wrinkled. Costa absent
..... *Hypnum* sp. (Pl. 12-8)

13532

- Costa complete; foliar cells polygonal; margin simply denticulate
..... *Plagiomnium* sp. (Pl.12-1)

23212

- Presence of tiny glandular hairs (white in fossil state) on both sides of leaf
..... *Myrica gale* (Pls. 5-3, 5-1, 3-2, 30-11)

31114

- (a) Leaf outline spatulate-linear; width approximately 2 mm; surface glossy in fossil state *Taxus canadensis* (Pl. 5-7)
(aa) Leaf outline different from above b
(b) Apex pointed-acuminate. Abaxial surface composed of straight hairs
..... *Andromeda glaucophylla* (Pl. 2-9)
(bb) Apex pointed-blunt. Abaxial surface composed of curved hairs (in the fossil state, there is a possibility of confusion with (b)) *Kalmia polifolia* (Pl. 15-5)

31136

- (a) Resiniferous canals intermittent. Some canal-associated swelling apparent on surface *Picea glauca* (Pl. 5-10)
(aa) Resiniferous canals continuous. Two continuous lines sometimes visible on surface *Picea mariana* (Pls. 15-2, 5-6, 5-12)

31245

Leaves attenuate in long direction from base toward tip. Leaf base often curved. Petiole included within overall length of leaf. Resiniferous canals laterally exiting (12X) *Larix laricina* (Pl. 17-3)

31341

Leaf base flattened, pad-like *Abies balsamea*

31433

Leaf opaque, with a whitish row of stomata underneath
..... *Juniperus communis* (Pl. 6-1)

32135

- (a) Resiniferous canals visible on smooth face of leaf *Pinus resinosa*
(aa) Resiniferous canals not visible *Pinus banksiana* (Pl. 5-8)

32145

Leaves usually denticulate on the three corners at apex; base often decomposed and polymorphic in peat matrix Cyperaceae

33212

Leaf glossy in fossil state. Petiole generally straight and offset with respect to leaf axis *Tsuga canadensis*

41133

- (a) Leaf spiny, without resiniferous vesicle *Lycopodium* sp. (Pl. 31-10)
(aa) Leaf spiny, with resiniferous vesicle on dorsal face *Thuja occidentalis*

3. Key to seeds

This key is based on identification of the outline characteristics, shape of cross section perpendicular to the major axis of the specimen, and type of surface relief. It is used for the identification of seeds and of plant structures that might resemble seeds. In determining the characteristics that follow, no consideration has been given to appendices or projections.

3.1 Description of the classification criteria

3.1.1 Outline characteristics

- (1) Circular: *Menyanthes trifoliata*
- (2) Angular: *Chamaedaphne calyculata*
- (3) Elliptic: *Andromeda glaucophylla*
- (4) Lanceolate: *Picea* sp.
- (5) Elongate-linear: *Ledum groenlandicum*

3.1.2 Shape of cross section perpendicular to the major axis of the specimen

- (1) Circular: *Cenococcum* sp.
- (2) Triangular: *Carex oligosperma*
- (3) Elongate-elliptic: *Abies balsamea*

3.1.3 Type of surface relief

The characteristics of the seed surface are important. They should be examined on the flattened surfaces (if possible), far from the hilum, if present, and at a magnification of 10X (hand lens). The illustrated glossary contains examples of the types of relief.

Five alternatives are proposed:

- (1) Glossy: An absence of any structure capable of deflecting the illumination light must be noted. A luminous point must be apparent on the surface of the seed. At higher magnification, there might be a network of some kind visible, but this detail is not taken into account, for example *Menyanthes trifoliata*
- (2) Dull: The tegument surface reflects little or no light. The outline of the luminous point defined in (1) is either scarcely visible or absent; type example: *Scirpus americanus*
- (3) Reticulate, colliculate, scalariform. An apparent relief prevents the surface from being regular, for example *Chamaedaphne calyculata*.
- (4) Sulcate: For example, *Pinus banksiana*.
- (5) Others.

3.2 Key to specific identification of seeds

112

- (a) Seed wrinkled close to hilum; hilum covering almost one quarter of surface. Tegument sometimes corrugate *Taxus canadensis* (Pl. 7-2)
- (aa) Specimen black, subspherical, having no visible features on the surface. Diameter 0.3-5 mm. Belongs to a lower fungus order *Cenococcum geophilum* (Pl. 31-12)

131

- (a) Seed having hilum at edge, with a thick tegument. In the fossil state seed often broken in half *Menyanthes trifoliata* (Pl. 9-11)
- (aa) Seed usually black, with slightly concave surface. In the fossil state seed often with a few spiked bristles at one of extremities *Polygonum lapathifolium* (Pl. 11-8)

132

- (a) Seed having an appendage at each end b
- (aa) Other types of seeds c
- (b) Seed having a narrowing trend toward base, forming an appendix; turgid appearance near tip *Carex stipata* (Pl. 10-6, 13-6)
- (bb) Other types of seeds, with blunt tip and base more or less stipitate *Carex stricta*
- (c) Seed, usually brown-beige; hilum located on one more or less flat surface *Potentilla palustris* (Pl. 6-9)
- (cc) Seed with a "trap-door" at side *Potamogeton* sp. (Pl. 31-5)

212

- Structure more or less cylindrical, composed of several rows of scales *Larix laricina* (mesoblast) (Pl. 16-11)

222

- (a) Small seed (approximately 1 mm); at higher magnification, tegument is reticulate
..... *Vaccinium myrtilloides* (Pl. 6-4)
- (aa) Seed (approximately 3 mm) with flattened base and bent style
..... *Carex oligosperma* (Pl. 10-10)

223

- Seed having a scalariform network over at least one face, often resembling the shape
of a piece of pie *Chamaedaphne calyculata* (Pl. 6-2)

232

- (a) Seed having elongated resiniferous pockets up to and beyond half the seed length
..... *Abies balsamea*
- (aa) Seed shriveled lengthwise, with a noticeable fold or crease in the middle; style per-
sistent *Carex crinita* (Pl. 11-4)

312

- (a) Specimen composed of less than 10 scales; tip of at least the first two scales upturned
slightly (opposed) *Thuja occidentalis* (cone)
- (aa) Specimen composed of more than 12 scales b
- (b) Specimen elongate and cylindrical, in excess of 2.5 cm; outline of tip of wing at least
1.5 mm from tip of scale *Picea glauca* (cone) (Pl. 7-3)
- (bb) Specimen more or less globular c
- (c) Scales thicker at tip, nondenticulate and subelliptic; top side of scale more or less
smooth d
- (cc) Scales thin, subcircular, with a denticulate tip; top side of scale rugose
..... *Picea mariana*
- (d) Traces of seed wings on concave face of scale parallel; bracteal subtending scale,
emarginate and flabelliform *Tsuga canadensis*
- (dd) Traces of seed wings on concave face of scale divergent; bracteal clearly mucronate;
cone well-preserved, embossed at base ... *Larix laricina* (cone scale) (Pl. 16-4)

322

- (a) Seed truncate at base; style long and straight *Carex limosa* (Pl. 11-3)
- (aa) Other seed types b
- (b) Seed approximately 5 mm; dorsal surface sulcate
..... *Nemopanthus mucronata* (Pl. 6-10)
- (bb) Other seed types, style persistent c
- (c) Seed corners paler than sides, approximately 1.5 mm
..... *Carex paupercula* (Pl. 10-5)
- (cc) Corners same color as sides; approximately 3 mm; perigynium pubescent
..... *Carex lasiocarpa* (Pl. 11-6)

331

- Seed small (approximately 2 mm), with hilum on the edges at tip
..... *Andromeda glaucophylla* (Pl. 6-6)

332

- (a) Specimen dark or pale, composed of an assemblage of leaves. (Partial desiccation is
an aid in verification refer to Key to leaves)
- (aa) Unadorned specimen (seeds) b (*Carex* spp.)
- (b) Seed with angular outline; tip blunt; base more or less cuneiform; sides converging
toward tip c
- (bb) Other types of seed d
- (c) Seed small; sides converging progressively toward tip; line joining tip to base, recti-
linear from one side of seed *Carex cephalantha* (Pl. 10-8)
- (cc) Seed with sides converging abruptly toward tip. Line joining tip to base, not recti-
linear *Carex exilis* (Pl. 10-9)
- (d) Seed with sides subparallel, having a subspatulate outline; style dehiscent, tip trun-
cate, base angle $< 90^\circ$ *Carex trisperma* (Pl. 10-12)
- (dd) Seed nonspatulate e
- (e) Seed with imperfect bilateral symmetry; style persistent, base angle $< 90^\circ$
..... *Carex aquatilis* (Pl. 10-7)

- (ee) Other types of seed f
- (f) Tip blunt, base angle approximately 90° *Carex canescens* (Pl. 10-11)
- (ff) Tip truncate, base more or less stipitate *Carex chordorrhiza*

412

- (a) Seed speckled overall (length 3.8–7.5 mm), shaped like an elongated disk f
- (aa) Other types of seed b
- (b) Specimen pale, elastic when squeezed, composed of several leaves intimately imbricated and resembling a seed *Sphagnum* sp. (apical bud) (Pl. 22-6)
- (bb) Other types of seed c
- (c) Seed truncate, pale at one end, cuneiform–apiculate at the other; length approximately 3 mm *Cladium mariscoides* (Pl. 26-6)
- (cc) Other types of seed d
- (d) Seed appendiculate at one end; sometimes partially covered by a membrane *Larix laricina* (Pl. 16-10)
- (dd) Other types of seed e
- (e) Seed pale, with longitudinally arranged resiniferous pockets *Juniperus communis*
- (f) Seed length 3.8–4.9 mm *Pinus resinosa* (Pl. 7-4)
- (ff) Seed length 6.0–7.5 mm *Pinus strobus* (Pl. 6-11)

422

- (a) Seed with triangular outline; length variable (1–2 mm to 2–3 mm) b
- (aa) Seed somewhat elongate in appearance c
- (b) Seed small (1–2 mm) f
- (bb) Seed somewhat larger, blackish, planoconvex g
- (c) Seed with blunt tip, without appendix; base slightly tapered and more or less stipitate *Eriophorum spissum* (Pls. 10-3, 15-6)
- (cc) Seed with pointed tip, with appendix d
- (d) Seed with blunt corners *Eriophorum virginicum* (Pl. 10-4)
- (dd) Seed with sharp corners e
- (e) Length < 2.1 mm *Eriophorum gracile*
- (ee) Length > 2.35 mm *Eriophorum angustifolium*
- (f) Seed corners paler than faces; tip of perigynium straight and clearly bidentate *Carex rostrata*
- (ff) Corners same color as faces; tip of perigynium curved; seed tip truncate and mucronate *Carex flava* (Pl. 11-1)
- (g) Seed blackish; basal angle approaching 90° *Scirpus heterochaetus*
- (gg) Seed with basal angle approaching 45° *Scirpus acutus* / *S. validus* (Pl. 24-4)

431

- Seed glossy, with a more-or-less globular projection at tip *Eleocharis palustris* (Pl. 19-8)

432

- (a) Seed dark b
- (aa) Seed pale c
- (b) Seed having some traces of resiniferous pockets; pockets small, length not exceeding half seed length *Tsuga canadensis* (Pl. 6-12)
- (bb) Other types of seed; easily confused with *Picea mariana* *Picea glauca* / *P. mariana*
- (c) Seed tapered at both ends; clear demarcation between style and body of seed *Rhynchospora alba* (Pl. 9-12)
- (cc) Seed truncate at one end. At higher magnification (30X), traces of the two fleshy wings of the fruit noticeable at base of seed *Myrica gale* (fruit without wings) (Pl. 6-7)

434

- Seed black, with a few longitudinal grooves on one of the faces *Pinus banksiana* (Pl. 7-5)

512

- (a) Seed clearly elongate, cylindrical b
- (aa) Seed small (< 2 mm), brownish c
- (b) Seed reticulate at one end and striate at the other *Calla palustris*
- (bb) Seed with triangular cross section at one end *Carex pauciflora* (Pl. 11-2)
- (c) Seed with a very visible ridge (cord) traversing length of seed
..... *Vaccinium oxycoccos* (Pl. 6-3)
- (cc) Other types of seed, with a small black spot at each end
..... *Vaccinium uliginosum* (Pl. 6-5)

522

- Seed pale, approximately 5 mm; dorsal surface sulcate (refer also to 322)
..... *Nemopanthus mucronata* (Pl. 6-10)

531

- Seed tapered at both ends *Carex* sp. (Ovales) (*Carex* sp. two-sided) (Pl. 18-3)

532

- (a) Seed winged, with a few traces of elongated resiniferous vesicle
..... *Thuja occidentalis* (Pl. 7-6)
- (aa) Seed often with a few barbed bristles at base, extending beyond tip, or nearly so
..... *Dulichium arundinaceum*

4. Complementary key

This key includes the following objects: fruit, bud scales, opaque bark bits, wood fragments, mesoblasts, oogoniums, hydathodes, sporangia, opercula, ephippia, statoblasts, sclerotia, and mycorrhizae.

The key is based on the outline type, form of the cross section perpendicular to the major axis, and type of structures noted on the specimen.

4.1 Description of the classification criteria

4.1.1 Outline type

- (1) Circular: Fruit of *Chamaedaphne calyculata*
- (2) Hemicyclic: Case (ocrea) of *Equisetum* sp.

- (3) Elliptic: Cone of *Larix laricina*
- (4) Lanceolate: Nodule of *Alnus rugosa*
- (5) Spatulate-linear: Bark of conifers

4.1.2 Form of the cross section perpendicular to the major axis

- (1) Circular: Mesoblast of *Larix laricina*
- (2) Semicircular: Operculum of *Sphagnum* spp.
- (3) Elliptic: Fruit of *Myrica gale*
- (4) Lanceolate:
- (5) Spatulate-lanceolate: Rachis of the Filicinae

4.1.3 Type of structures

- (1) Unadorned: Wood fragment
- (2) Composed of several elements: Mesoblast of *Larix laricina*

4.2 Specific identification key of the "VARIA"

112

Structure composed of a verrucose pedicel, scales (sepals), a globular part half enclosed by scales, and an appendix at the tip. The two first scales are opposed. Presence of microplates, especially on the scales and the pedicel *Chamaedaphne calyculata* (fruit) (Pl. 28-7)

121

Specimen cupola- or dome-shaped. It covers and encloses the capsule of the Sphagnales *Sphagnum* sp. (operculum) (Pl. 30-7)

132

Specimen triradiate, composed of two lateral wings and central seed. Possibly presence of whitish glands on fossilized specimen, if well preserved *Myrica gale* (fruit) (Pl. 6-7)

152

Specimen small, discoidal (approximately 1 mm), with multiple glochidiate rays on periphery *Cristatella mucedo* (statoblast) (Pl. 31-7)

251

- (a) Structure small (approximately 0.5 mm), thin, hemilanceolate *Daphnia* sp. (ephippium) (Pl. 31-3)
- (aa) Structure encasing and dentate-digitate b
- (b) Sheath (or fragment) pale at base, with blackish teeth. Central cavity covering half, or more, of stem or rhizome, if present. Lateral cavity invisible, or barely visible, to the naked eye *Equisetum fluviatile*
- (bb) Sheath of other type, but digitate *Equisetum* sp. (Pl. 17-4)

311

Specimen small (approximately 0.5 mm), ellipsoidal, surface covered with helicoidal ridges (more than eight) *Chara* sp. (oogonium) (Pl. 31-4)

312

- (a) Specimen (approximately 1 mm), composed of more than 10 scales; if well-preserved, embossed at the base (refer also to 312, Key to seeds) *Larix laricina* (cone) (Pl. 16-4)
- (aa) Specimen cylindrical, composed of several rows of scales intimately imbricated (refer also to 212, Key to seeds) *Larix laricina* (mesoblast) (Pl. 16-11)

331

- (a) Structure thin and elongate (approximately 1 cm), resembling exactly the "finger and nail" *Scheuchzeria palustris* (hydathode) (Pl. 9-9)
- (aa) Structure dull, finely lined, with corners somewhat rounded (mechanical erosion), composed of tubular microfibers wood fragment (Pl. 13-3)

NOTE: The absence of "pores" in the annual rings is a diagnostic criterion for "conifer wood." The presence of "pores," visible by hand lens or by the naked eye, indicates "deciduous wood."

332

Specimen subglobular, small (approximately 0.2 mm), composed of dark-colored axis and dehiscent vesicle Polypodiaceae (sporangium) (Pl. 17-6)

412

Structure dark-colored, pyriform (approximately 5 mm), mucronate at tip. A number of these structures may collect to form a dendritic assemblage *Alnus rugosa* (nodule)

521 (refer to 331 (aa))

551

- (a) Structure lamellar b
- (aa) Structure elongate, more or less cylindrical; foliar scars, if present, opposed; vascular scar unique and irregular Filicinae (rachis)
- (b) Structure opaque, with subregular network of cells Conifer (bark) (Pl. 13-5)
- (bb) Structure of another type c
- (c) Structure translucent, outline elongate or circular Herbaceae (epidermis)
- (cc) Structure opaque, blackish, same outline as above Filicinae (epidermis) (Pl. 29-10)

MACROPHOTOGRAPHS

Reference materials

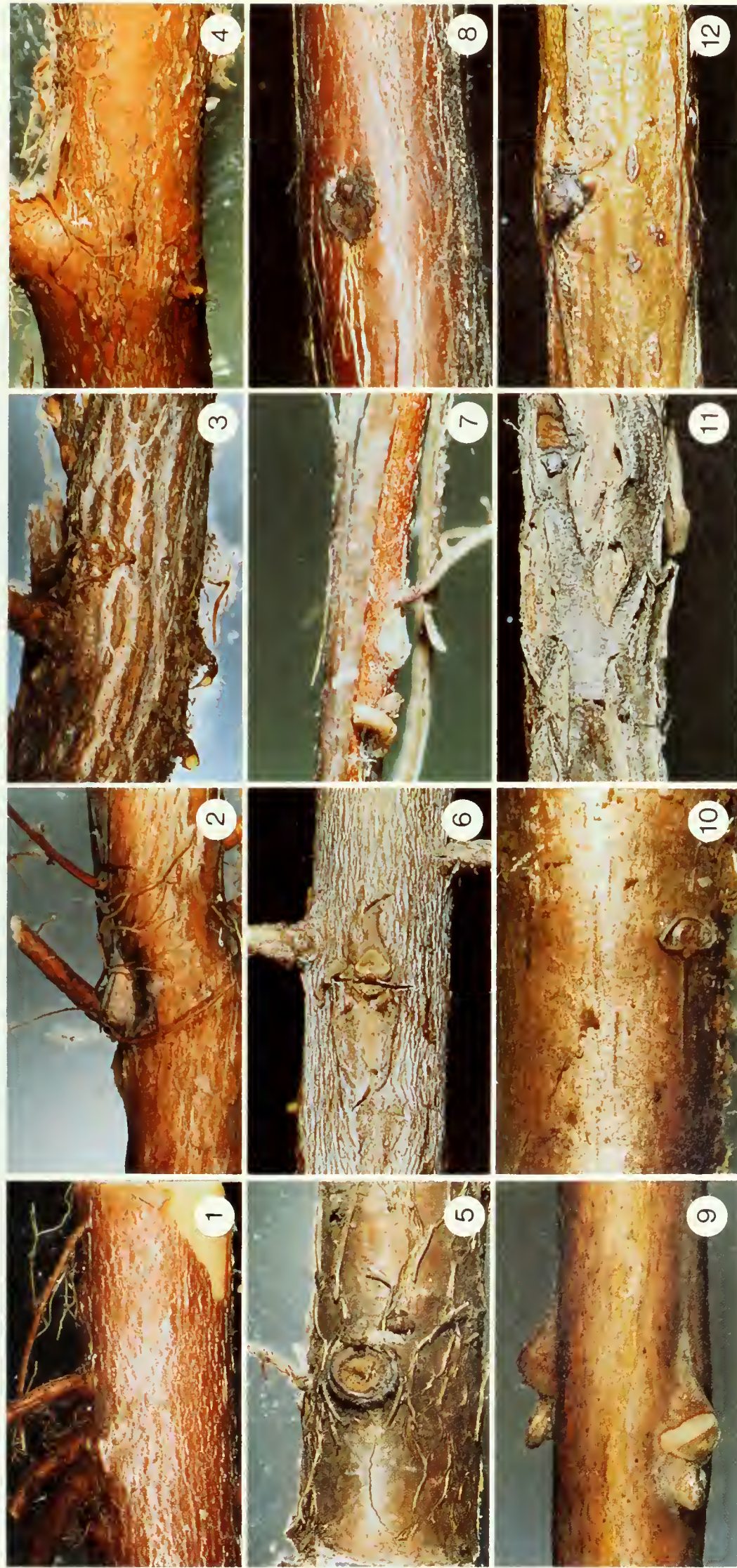


PLATE 1

LIGNOSAE

Underground stems

- 1-1 *Chamaedaphne calyculata* ×8
- 1-2 *Andromeda glaucophylla* ×8
- 1-3 *Kalmia angustifolium* ×8
- 1-4 *Vaccinium angustifolium* ×5

Aerial stems

- 1-8 *Chamaedaphne calyculata* ×9

- 1-5 *Myrica gale* ×5

- 1-6 *Ledum groenlandicum* ×8

- 1-7 *Vaccinium oxycoccos* ×1.5

- 1-9

- Andromeda glaucophylla* ×12

- 1-10 *Vaccinium angustifolium* ×9

- 1-11 *V. angustifolium* ×6

- 1-12 *V. angustifolium* ×6

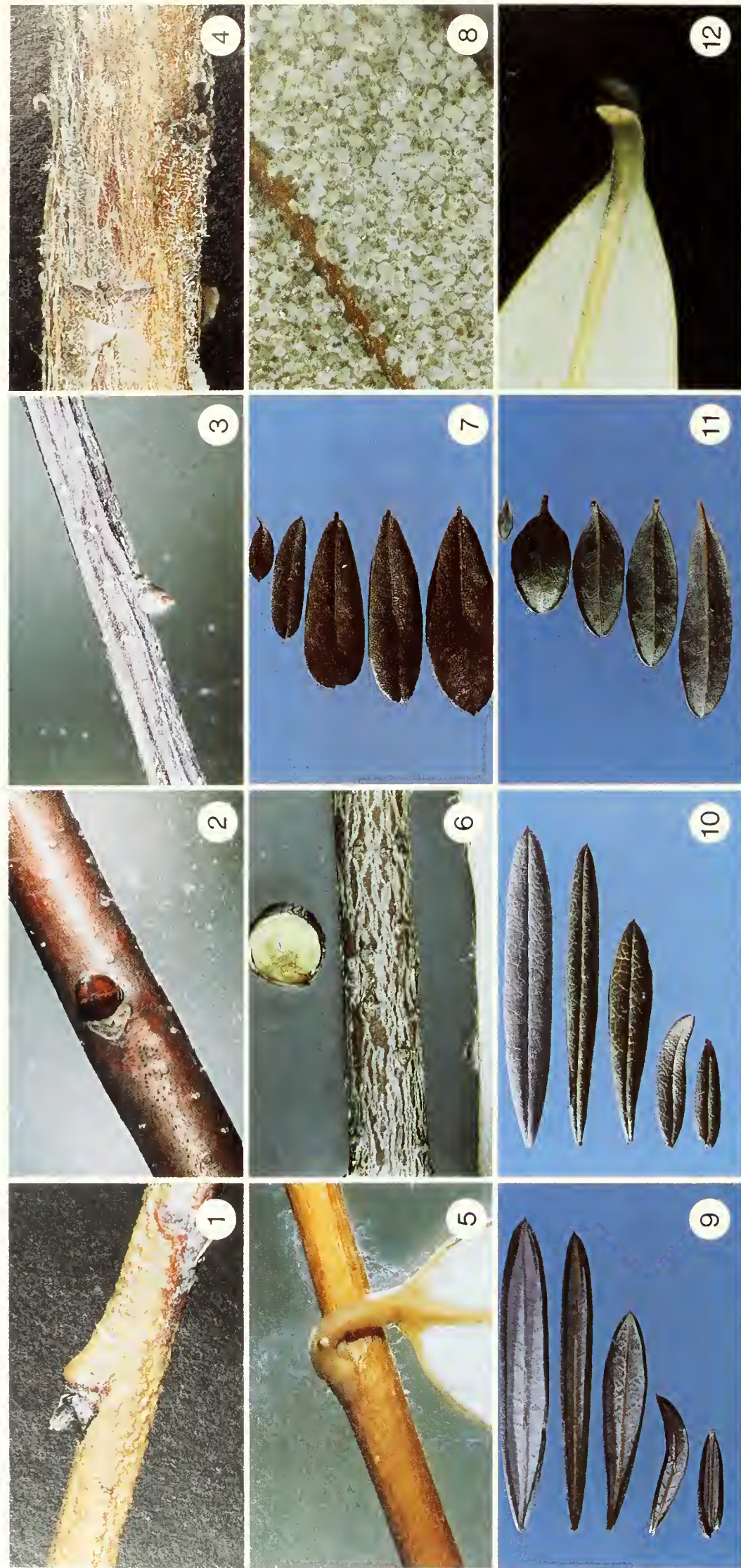


PLATE 2

LIGNOSAE

Aerial stems

2-1 *V. angustifolium* ×9

2-2 *Myrica gale* ×15

2-3 *M. gale* ×3

2-4

Ledum groenlandicum ×10

2-5 *Vaccinium macrocarpon* ×1.5

2-6 *Nemopanthus mucronata* ×2.5

Leaves

2-7 *Chamaedaphne calyculata* (upper face) ×1.5

2-8

C. calyculata (lower face peltate) ×75

2-9 *Andromeda glaucophylla* (lower face) ×1.5

2-10 *A. glaucophylla* (upper face) ×1.5

2-11 *Kalmia angustifolia* (upper face) ×1.5

2-12 *K. angustifolia* (leaf blade and petiole) ×2.5



PLATE 3

LIGNOSAE

Leaves

- 3-1 *Vaccinium angustifolium* $\times 1.5$
- 3-2 *Myrica gale* $\times 1.0$
- 3-3 *Ledum groenlandicum* $\times 1.2$
- 3-4 *L. groenlandicum* $\times 1.2$

3-5

- Vaccinium oxycoccos* (upper face) $\times 1.5$
- 3-6 *V. oxycoccos* (upper face) $\times 1.5$
- 3-7 *V. macrocarpon* (upper face) $\times 1.5$
- 3-8 *V. macrocarpon* (lower face) $\times 1.5$

Roots

- 3-9 *Chamaedaphne calyculata* $\times 8$
- 3-10 *Myrica gale* (with mycorrhizae) $\times 10$
- 3-11 *Alnus rugosa* (with mycorrhizae) $\times 0.5$

Branches

- 3-12 *Ledum groenlandicum* (annual growth) $\times 12$

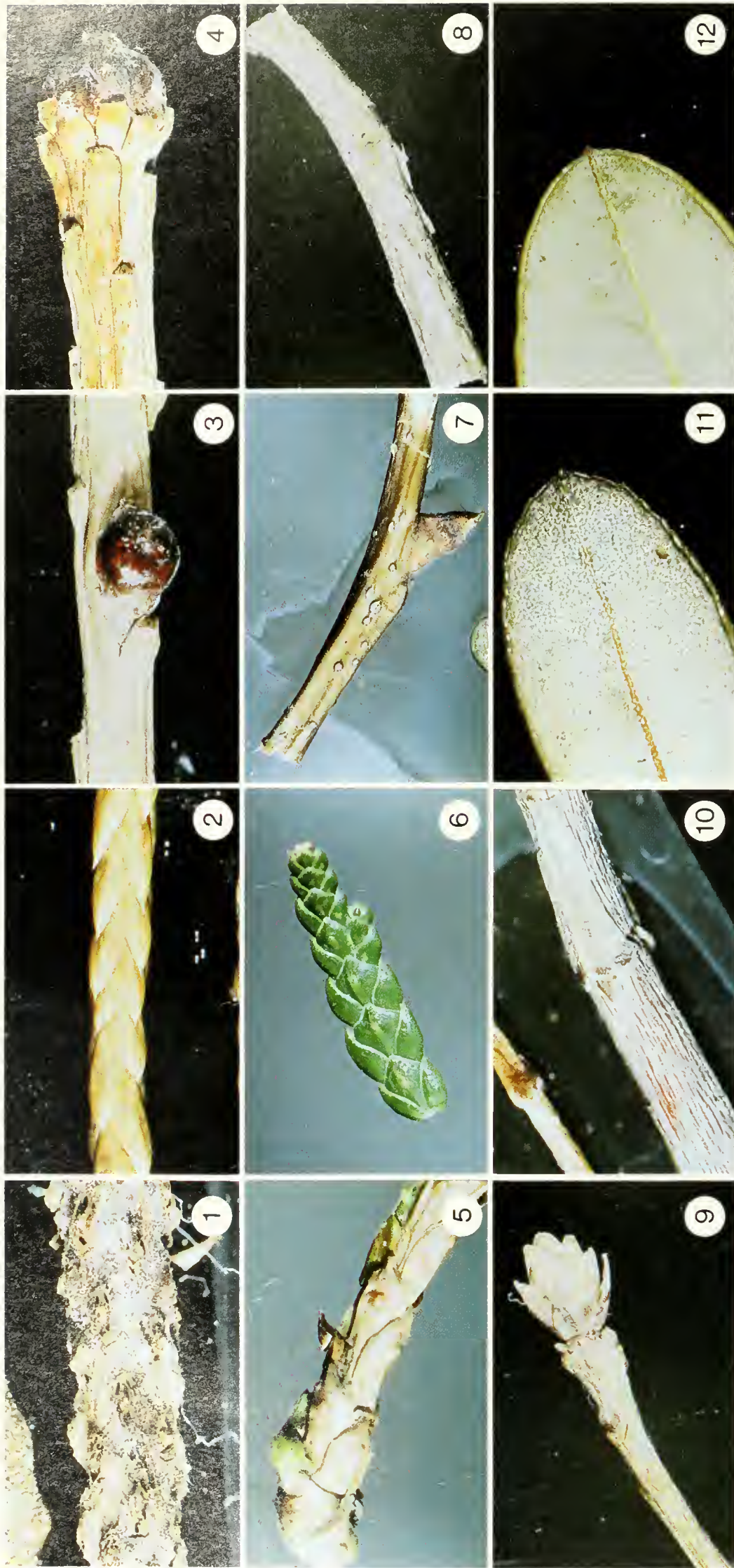


PLATE 4

LIGNOSAE

Branchlets

- 4-1 *Abies balsamea* ×5
- 4-2 *Juniperus horizontalis* ×5
- 4-3 *Larix laricina* ×5
- 4-4 *L. laricina* ×5

- 4-5 *Thuja occidentalis* ×5

- 4-6 *T. occidentalis* ×3

- 4-7 *Nemopanthus mucronata* ×2.5

- 4-8 *Rhododendron canadensis* ×2.5

- 4-9 *R. canadensis* ×2.5

- 4-10 *Kalmia polifolia* ×3

Leaf margins and apices

- 4-11 *Chamaedaphne calyculata* ×2.5

- 4-12 *Kalmia angustifolia* ×2.5

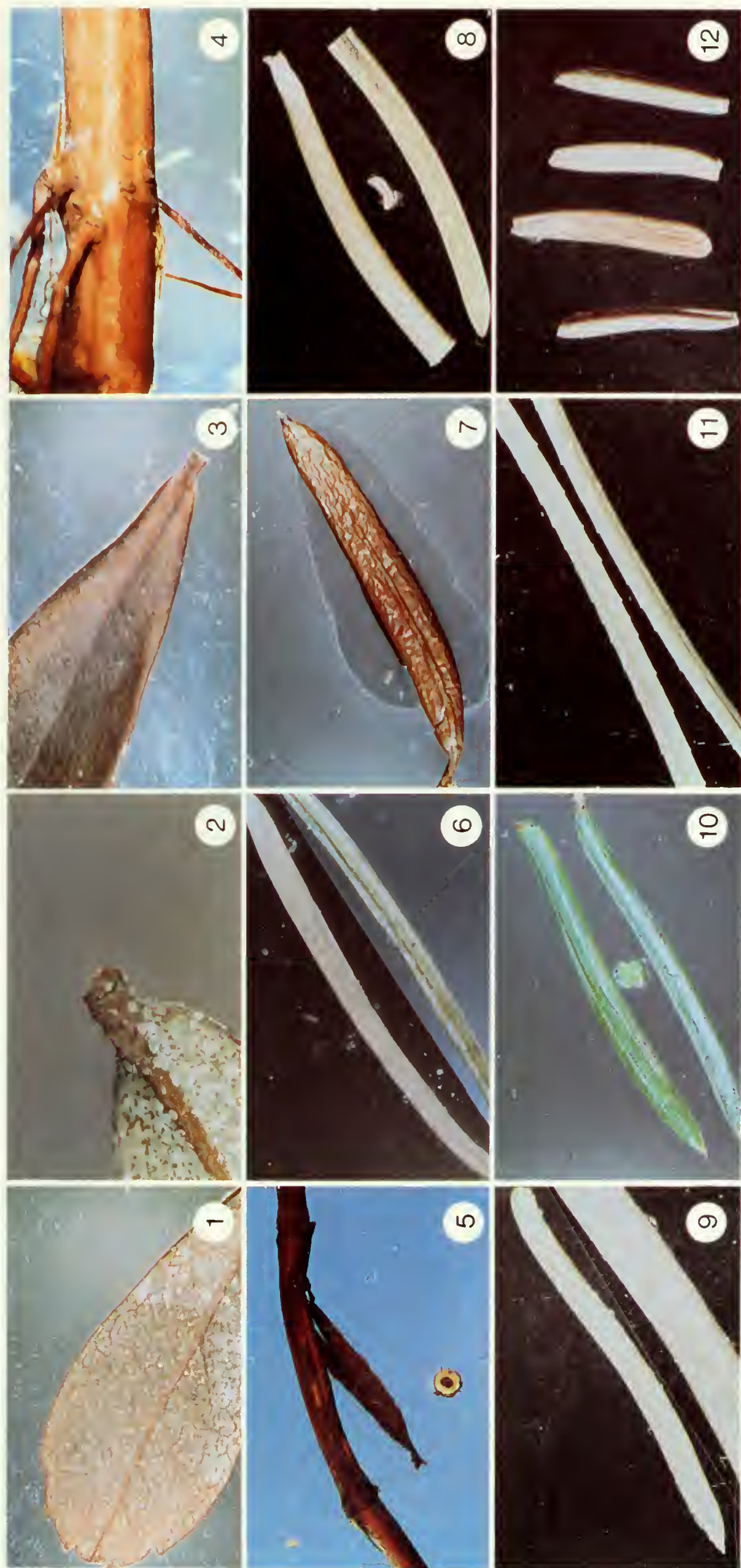


PLANCHE 5

LIGNOSAE

Marges et apex foliaires

5-1 *Myrica gale* ×5

Pétioles

5-2 *Chamaedaphne calyculata* ×50

5-3 *Myrica gale* ×5

Rhizomes

5-4 *Potentilla palustris* ×5

5-5 *P. palustris* ×5

Aiguilles

5-6 *Picea mariana* ×10

5-7 *Taxus canadensis* ×2,5

Pinus banksiana ×2

Picea glauca ×3

P. glauca 3×

Pinus strobus ×4,5

Picea mariana ×3



PLATE 6

LIGNOSAE

Needles

6-1 *Juniperus communis* ×2.5

Seeds

6-2 *Chamaedaphne calyculata* ×8

6-3

Vaccinium oxycoccos ×6

6-4

V. myrtilloides ×8

6-5

V. uliginosum ×9

6-6

Andromeda glaucophylla ×9

6-7

Myrica gale a + b ×6

6-8

Picea mariana ×6

6-9

Potentilla palustris ×16

6-10

Nemopanthus mucronata ×8

6-11

Pinus strobus ×9

6-12

Tsuga canadensis ×6

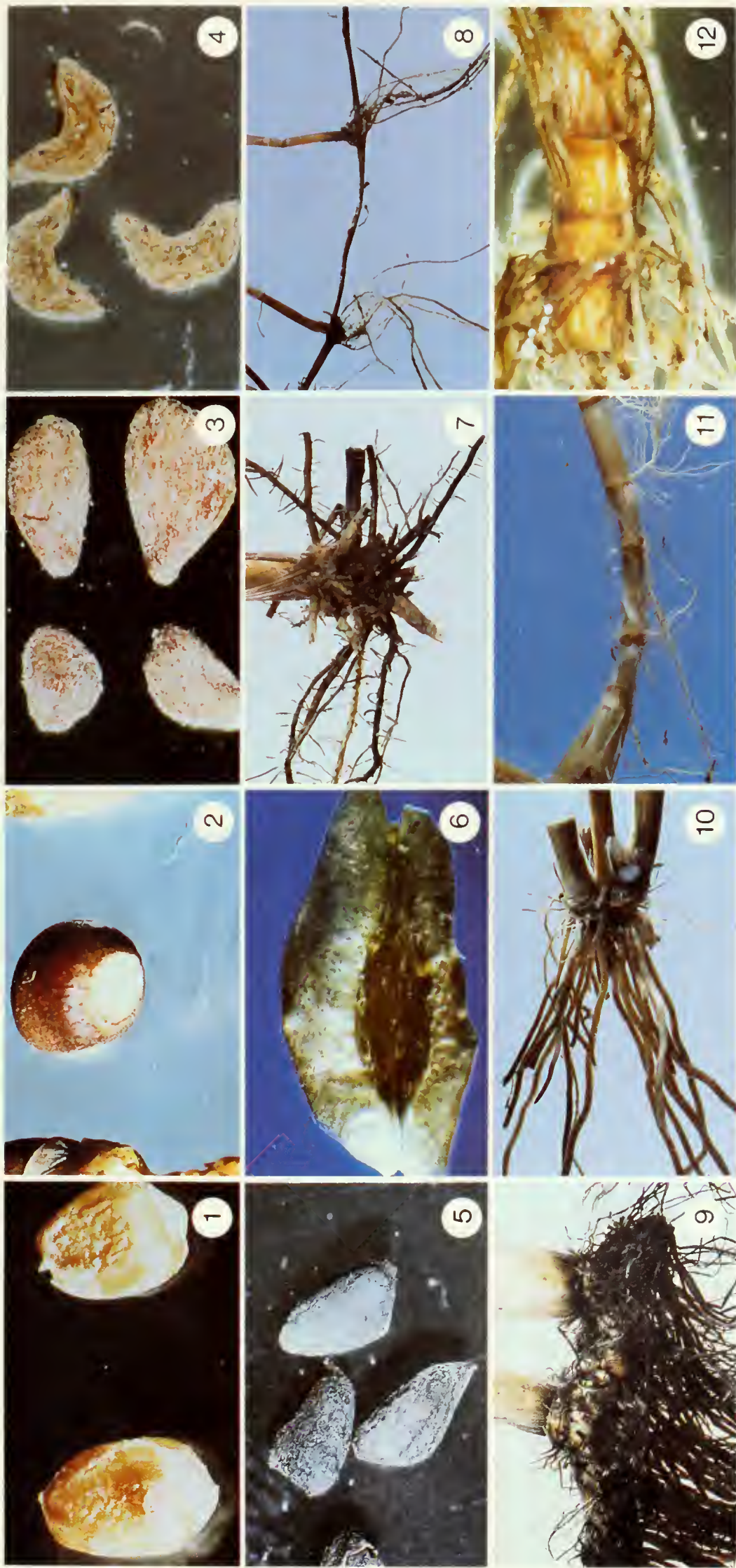


PLATE 7

LIGNOSAE

Seeds

- 7-1 *Juniperus horizontalis* $\times 6$
- 7-2 *Taxus canadensis* $\times 2.5$
- 7-3 *Picea glauca* $\times 6 + \times 12$
- 7-4 *Pinus resinosa* $\times 12$

- 7-5 *P. banksiana* $\times 4 + \times 3$
- 7-6 *Thuja occidentalis* $\times 1.5$

HERBACAE

Crowns

- 7-7 *Cladium mariscoides* $\times 0.8$

- 7-8
- 7-9
- 7-10
- 7-11
- 7-12

- Eleocharis elliptica* $\times 0.5$
- Scirpus validus* $\times 0.5$
- Juncus effusus* $\times 0.5$
- Scheuchzeria palustris* $\times 0.5$
- Eriophorum gracile* $\times 0.5$



PLANCHE 8

HERBACAE

Collets

- 8-1 *Typha* sp. $\times 0,5$
- 8-2 *Calla palustris* $\times 0,5$
- 8-3 *Carex* sp. $\times 2,0$
- 8-4 *C. lasiocarpa* $\times 0,5$

- 8-5 *C. stricta* $\times 0,7$
- 8-6 *Eriophorum virgincum* $\times 1,0$
- 8-7 *E. spissum* $\times 1,0$

Rhizomes

- 8-8 *Cladium mariscoides* $\times 0,5$

- 8-9 *Menyanthes trifoliata* $\times 0,5$
- 8-10 *Eriophorum spissum* $\times 0,8$

Surface des racines

- 8-11 *Cladium mariscoides* $\times 12$
- 8-12 *Eleocharis elliptica* $\times 9$



PLANCHE 9

HERBACAE

Surface des racines

- 9-1 *Scirpus validus* ×8
 9-2 *Juncus effusus* ×12
 9-3 *Scheuchzeria palustris* ×5
 9-4 *Eriophorum gracile* ×24

- 9-5 *Typha* sp. ×9
 9-6 *Calla palustris* ×9
 9-7 *Carex lasiocarpa* ×6
 9-8 *C. limosa* ×12
 9-9 *Scheuchzeria palustris* (feuille avec hydathode à son extrémité) ×6

- 9-10 *Carex oligosperma* (infructescence) ×6

Graines

- 9-11 *Menyanthes trifoliata* ×9
 9-12 *Rynchospora alba* ×12

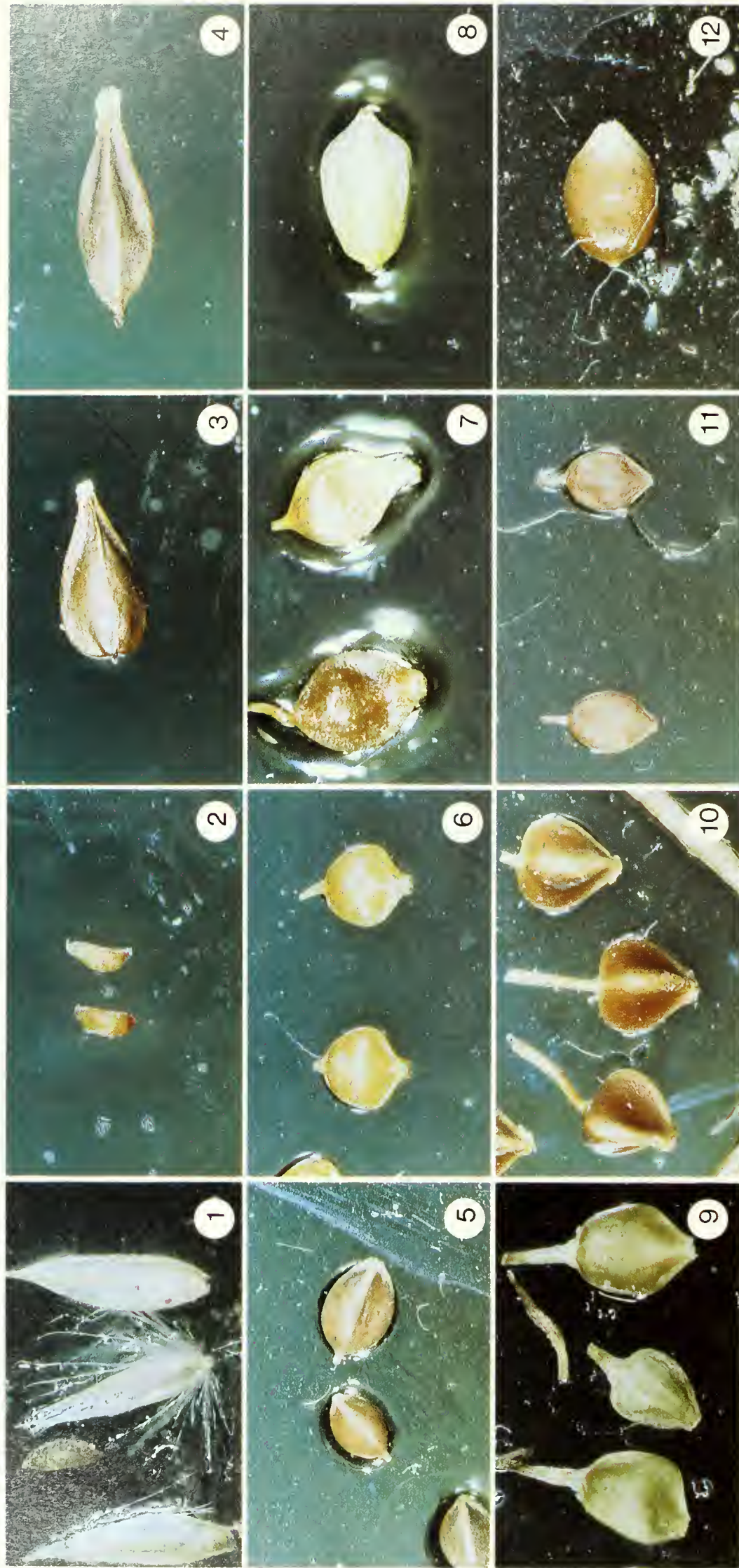


PLATE 10

HERBACEAE

Seeds

- 10-1 *Calamagrostis canadensis* ×15
 10-2 *Juncus effusus* ×24
 10-3 *Eriophorum spissum* ×12

- 10-4 *E. virginicum* ×15
 10-5 *Carex paupercula* ×9
 10-6 *C. stipata* ×12
 10-7 *C. aquatilis* ×18
 10-8 *C. cephalantha* ×18

- 10-9 *C. exilis* ×12
 10-10 *C. oligosperma* ×9
 10-11 *C. canescens* ×12
 10-12 *C. trisperma* ×12



PLATE 11

HERBACAE

Seeds (continued)

- 11-1 *Carex flava* ×16
- 11-2 *C. pauciflora* ×15
- 11-3 *C. limosa* ×16
- 11-4 *C. crinita* ×16
- 11-5 *C. gynocrates* ×18

- 11-6 *C. lasiocarpa* ×5

- 11-7 *C. interior* ×5

- 11-8 *Polygonum lapathifolium* ×3

MUSCINAE

Stems and branches

- 11-9 *Climacium americanum* ×12

- 11-10 *Dicranum undulatum* ×6

- 11-11 *Pleurozium schreberi* ×7

Leaves

- 11-12 *Climacium americanum* ×10

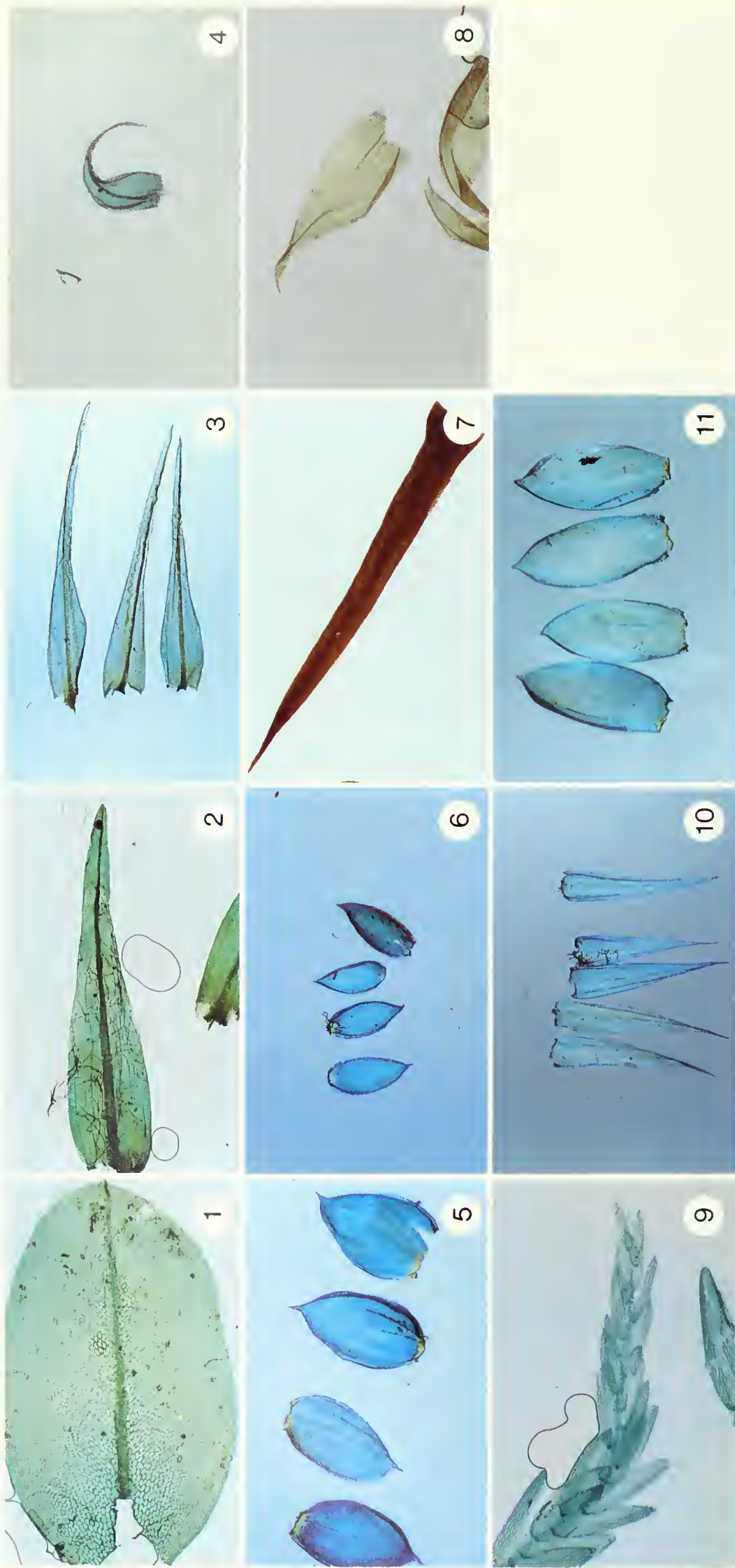


PLANCHE 12

MUSCINAE

Feuilles

- 12-1 *Mnium affine* (*Plagiomnium* sp.) × 8
 12-2 *Dicranum polysetum* × 6
 12-3 *D. undulatum* × 4, × 7

- 12-4 *Ptilium crista-castensis* × 12
 12-5 *Hypnum splendens* (feuille de tige) × 12
 12-6 *H. splendens* (feuille raméale) × 12
 12-7 *Polytrichum* sp. × 9
 12-8 *Hypnum luhbergii* × 12

- 12-9 *Sphagnum* sp. × 12
 12-10 *Tomenthypnum nitens* × 6
 12-11 *Pleurozium schreberi* × 7



PLANCHE 13

LIGNOSAE-HERBACAE

- 13-1 Fraction >2000 µm. Fragments de bois; tiges aériennes et souterraines. ×5
- 13-2 Fragments de tiges ou de rameaux arbustifs. Écorce lisse (gauche); jonction de rameaux (droite). ×6
- 13-3 Fragments de bois de conifère. Coupe transversale de faisceaux conducteurs (gauche); tissus parenchymateux formant les rayons (droite). ×6
- 13-4 Fraction 1000–2000 µm. Fragments de bois, racines et restes tissulaires d'Herbaceae. ×5
- 13-5 Fragment d'écorce de conifère. Cellules tannifères. ×15
- 13-6 Graine de *Carex crinita* (gauche), surface foncée et repli caractéristique; *Carex stipata* (droite) rétrécissement prononcé à la base. ×15
- 13-7 Racines d'Herbaceae. Noeud de racines secondaires et radicelles. ×10

- 13-8 Radicelles d'Herbaceae (gauche) et fragment de bois (droite) retenus ensemble par des hyphes fongiques. ×15
- 13-9 Fraction 450–1000 µm. Racines et radicelles d'Herbaceae, fragments de Lignosae et boulettes fécales. ×20

LIGNOSAE – HERBACAE – MUSCINAE

- 13-10 Fraction >2000 µm. Fragments de tige, d'écorce, de racines et de feuilles d'Ericaceae; racines fines d'Herbaceae; agrégats formés d'éléments macrofossiles et de matériaux fins. ×5
- 13-11 Fragment de tige d'Ericaceae (*Vaccinium* sp.). Assise foliaire et bourgeon avec deux écailles de garde. ×8
- 13-12 Fragment de tige souterraine et racine d'Ericaceae (v. *Vaccinium* sp.) Au point d'origine de la racine, des petites écailles caractéristiques. ×6

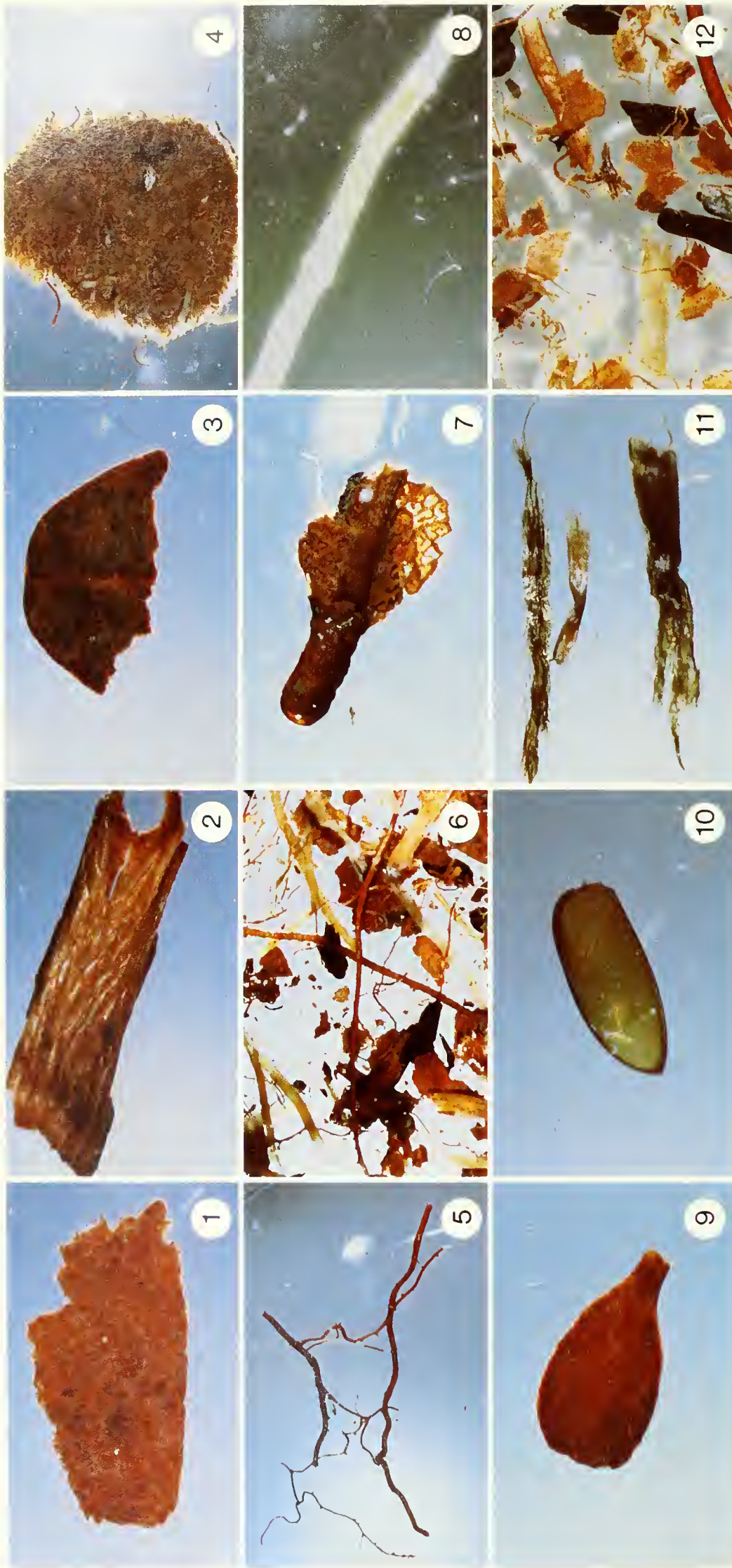


PLATE 14

LIGNOSAE - HERBACAE - MUSCINAE

- 14-1 Leaf fragment of *Chamaedaphne calyculata*. Margin slightly denticulate, and network of secondary vascular bundles visible. $\times 10$
- 14-2 Bark fragment of Ericaceae (cf. *Chamaedaphne* sp.). Surface reticulate and slightly encrusted. $\times 8$
- 14-3 Leaf (blade and apex) fragment of *Kalmia* sp. Margin smooth, tip slightly emarginate, central vascular bundle terminating at the apex. $\times 10$
- 14-4 Aggregate of fine materials. Radicles of Herbaceae; roots of Lignosae; and leaves of *Sphagnum* sp. $\times 4$
- 14-5 Roots of Lignosae (Ericaceae?). $\times 6$

- 14-6 Fraction 1000-2000 μm . Stem fragments of *Sphagnum* sp.; Lignosae bark; roots of Herbaceae; and carbonized woody fragments. $\times 6$
- 14-7 Petiole and leaf blade fragment of *Chamaedaphne calyculata*. $\times 12$
- 14-8 Bare stem fragment of *Sphagnum* sp. Foliar scars at regular intervals on the stem. $\times 10$
- 14-9 Complete leaf of Lignosae. $\times 15$
- 14-10 Insect elytra. $\times 15$
- 14-11 Fragment of Herbaceae stem. $\times 9$
- 14-12 Fraction 450-1000 μm . Leaves and stem of *Sphagnum* sp.; roots and stem of Ericaceae; leaves of Lignosae; and carbonized pieces. $\times 12$



PLATE 15

LIGNOSAE - HERBACAE - MUSCINAE

- 15-1 Leaf of *Sphagnum* sp. Characteristic arrangement of cells. $\times 9$
- 15-2 Needle of *Picea mariana*. Three rows of stomata and quadrangular section visible. Degeneration of tissues (extreme left). $\times 10$
- 15-3 Stem fragment of *Sphagnum* sp. Covered by hydrocytes. $\times 8$

LIGNOSAE - MUSCINAE - HERBACAE

- 15-4 Fraction $> 2000 \mu\text{m}$. Stem and root fragments of Lignosae; fragments of Herbacae; fragments of stem, branches, and leaves of Muscinae. $\times 5$
- 15-5 Complete leaf of Ericaceae (*Andromeda glaucophylla*/Kalmia polifolia). Leaf linear, obtuse, and revolute; lower surface canescent. $\times 6$

- 15-6 Seed of *Eriophorum spissum* (covered by its perigynium). $\times 18$
- 15-7 Leaf of *Pleurozium schreberi*. Apex bent, leaf cucullate; costa short and double. $\times 15$
- 15-8 Idem $\times 15$
- 15-9 Branches of *Sphagnum* sp., with leaves attached. $\times 15$
- 15-10 Bare stem of *Sphagnum* sp. Foliar scars at more or less regular intervals. $\times 8$
- 15-11 Stem of Muscinae (Bryale). Foliar scar and branch insertion point visible. $\times 8$
- 15-12 Stem and branches of *Sphagnum* sp. Foliar scar and branch insertion point visible. $\times 12$

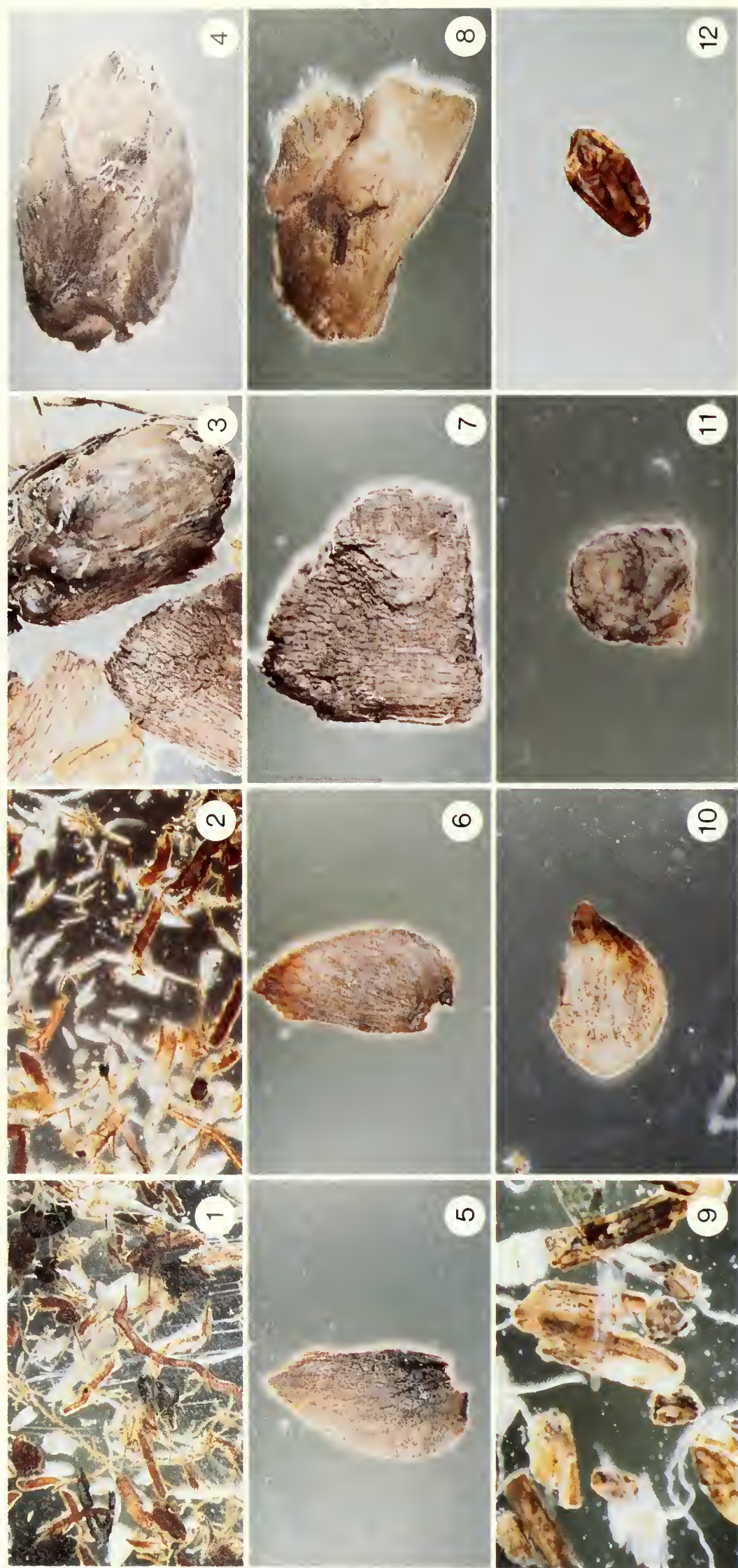


PLANCHE 16

LIGNOSAE – MUSCINAE – HERBACAE

- 16-1 Fraction 1000–2000 µm. Fragments de racines d'Ericaceae; tiges, rameaux et feuilles de Muscinæ; restes tissulaires et racines d'Herbaceae. ×5
 16-2 Fraction 450–1000 µm. Fragments de tiges et de rameaux de Sphagnum sp.; feuilles de Muscinæ (Bryale et Sphagnaceae); fragments de Lignosae. ×12

LIGNOSAE – HERBACAE – PTERIDOPHYTAE

- 16-3 Fraction >2000 µm. Fragments de bois et cône de Lignosae. ×5
 16-4 Cône de *Larix laricina*. Écailles de cône imbriquées. ×5

- 16-5 Écailles de cône de *Larix laricina*. ×6

Idem

- 16-6 Fragment de bois de conifère. ×6
 16-7 Fragment de Lignosae. ×6
 16-8 Fraction 1000–2000 µm. Racines fines d'Herbaceae; fragments de bois et d'écorce de Lignosae; fragments de Pteridophytæ. ×6
 16-9 Graine de *Larix laricina*. Surface réticulée et appendiculée à une extrémité. ×6
 16-10 Mésoblaste de *Larix laricina*. ×15
 16-11 Bourgeon de *Salix* sp. ×18



PLANCHE 17

LIGNOSAE - HERBACAE - PTERIDOPHYTAE

- 17-1 Fraction 450-1000 µm. Aiguilles de conifère, restes tissulaires et racines d'Herbaciae; fragments de Pteridophytæ. ×12
 17-2 Racine de Pteridophytæ/*Equisetum* sp. ×24
 17-3 Aiguille de *Larix laricina*, linéaire, sessile, triangulaire avec canaux résinifères à la marge. ×12
 17-4 Fragment de graine denticulée d'*Equisetum* sp. ×18
 17-5 Graine de *Carex trisperma*. Côtés parallèles. ×15
 17-6 Sporangie de Polypodiaceae. Présence de l'anneau caractéristique. ×24

HERBACAE

- 17-7 Fraction >2000 µm. Racines, rhizomes, restes tissulaires et tiges d'Herbaciae; un élytre d'insecte. ×5
 17-8 Fragment de tige avec noeud d'Herbaciae (Gramineae?). ×8
 17-9 Élytre d'insecte. ×12
 17-10 Racines fines et racelles d'Herbaciae. ×9
 17-11 Racines primaires et secondaires d'Herbaciae (Cyperaceae?). ×5
 17-12 Rhizome à noeuds rapprochés de Cyperaceae. ×8

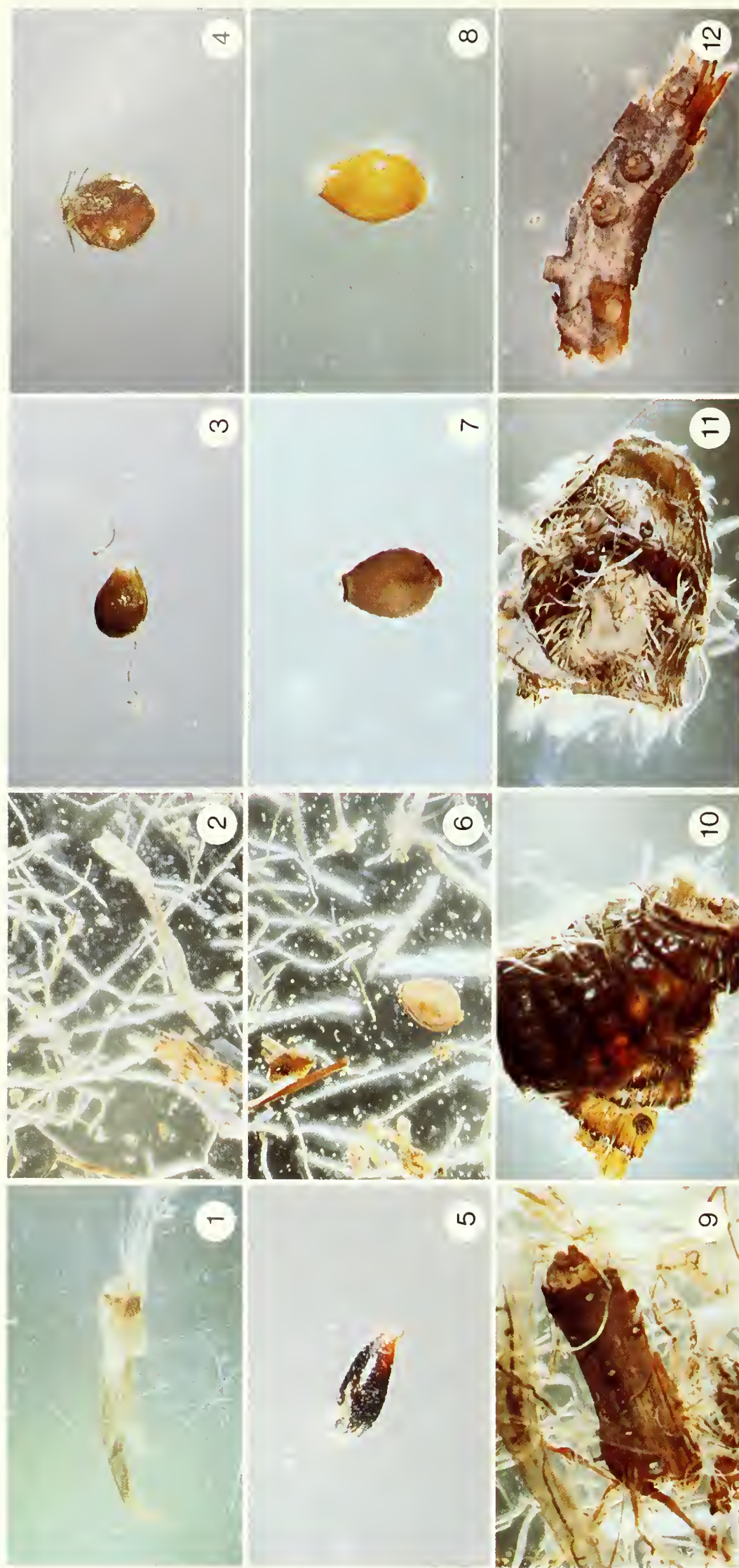


PLATE 18

HERBACAE

- 18-1 Part of sheathing base of Cyperaceae. $\times 6$
- 18-2 Fraction 1000–2000 μm . Roots and tissue remains of Herbaceae. $\times 6$
- 18-3 Seed of *Carex* sp. two-sided (subgenus *Vignea*), penetrated by a root of Herbaceae. $\times 9$
- 18-4 Seed of *Eleocharis* sp., with perigynium and bristles. $\times 12$
- 18-5 Insect femur. $\times 20$
- 18-6 Subgroup 450–1000 μm . Fine roots, tissue remains, and seed of Herbaceae. $\times 9$

- 18-7 Seed of *Eleocharis* sp. At lower end, seed cap is visible. $\times 7$
- 18-8 Seed of *Carex* sp. $\times 15$

HERBACAE – LIGNOSAE

- 18-9 Fraction $> 2000 \mu\text{m}$. Root fragments of Herbaceae; wood fragments of Lignosae. $\times 5$
- 18-10 Rhizome, with short internodal spacing, of *Carex* sp. $\times 5$
- 18-11 Idem
- 18-12 Root of Lignosae, with projections of secondary roots. $\times 6$



PLATE 19

HERBACAE - LIGNOSAE

- 19-1 Rhizome, with short internodal spacing, of *Carex* sp., with roots. $\times 6$
- 19-2 Stem of Gramineae, with node, and foliar conductive fascicles. $\times 10$
- 19-3 Tissue remains of Herbaceae. $\times 8$
- 19-4 Fraction 1000-2000 μm . Roots and tissue remains of Herbaceae; fragments of Lignosae. $\times 8$
- 19-5 Twig fragment (extremity) of Lignosae. $\times 12$
- 19-6 Secondary veins of a partially decomposed Lignosae leaf. $\times 12$
- 19-7 Secondary shoot at the extremity of a Lignosae branchlet. $\times 15$

- 19-8 Seed of *Eleocharis palustris*, oval-shaped, with seed cap and bristles. $\times 9$
- 19-9 Seed of *Carex* cf. *stipata*, partially freed from its perigynium. $\times 15$
- 19-10 Subgroup 450-1000 μm . Roots and tissue remains of Herbaceae; fragments of Lignosae. $\times 8$
- 19-11 Annual branchlet growth of *Picea mariana*; leaf attachment point all around the branchlet. $\times 15$

HERBACAE - LIGNOSAE (LA)

- 19-12 Fraction $> 2000 \mu\text{m}$. Fragments of Lignosae; rhizome of Herbaceae. $\times 5$



PLANCHE 20

HERBACAE – LIGNOSAE (LA)

- 20-1 Rhizome de Cyperaceae (noeud et point de jonction de racine près du noeud). ×5
- 20-2 Cocon d'insecte. ×5
- 20-3 Fragment de tige de Lignosae avec cicatrices de racines ou de rameaux. ×5
- 20-4 Fragment de tige de Lignosae arbustif. Vaisseaux conducteurs, excroissances et rainures d'insecte. ×5
- 20-5 Rameau de Lignosae arbustif. Bifurcation du rameau. ×6
- 20-6 Tige d'Ericaceae Écorce striée-anatomosée et jonction de rameaux. ×6

- 20-7 Tige de Lignosae arbustif. Écorce finement réticulée et jonction de rameau. ×6
- 20-8 Fragment de Lignosae avec cicatrice de rameau secondaire. ×6
- 20-9 Fragment de tige de Lignosae arbustif. Écorce et jonction de rameau. ×6
- 20-10 Fraction 1000–2000 µm. Racines d'Herbacae; fragments de tige et écorce de Lignosae arbustif et de *Larix laricina*. ×6
- 20-11 Fragment de bois de conifère avec rayons sclérénchymateux. ×12
- 20-12 Mésoblaste de *Larix laricina*. ×12

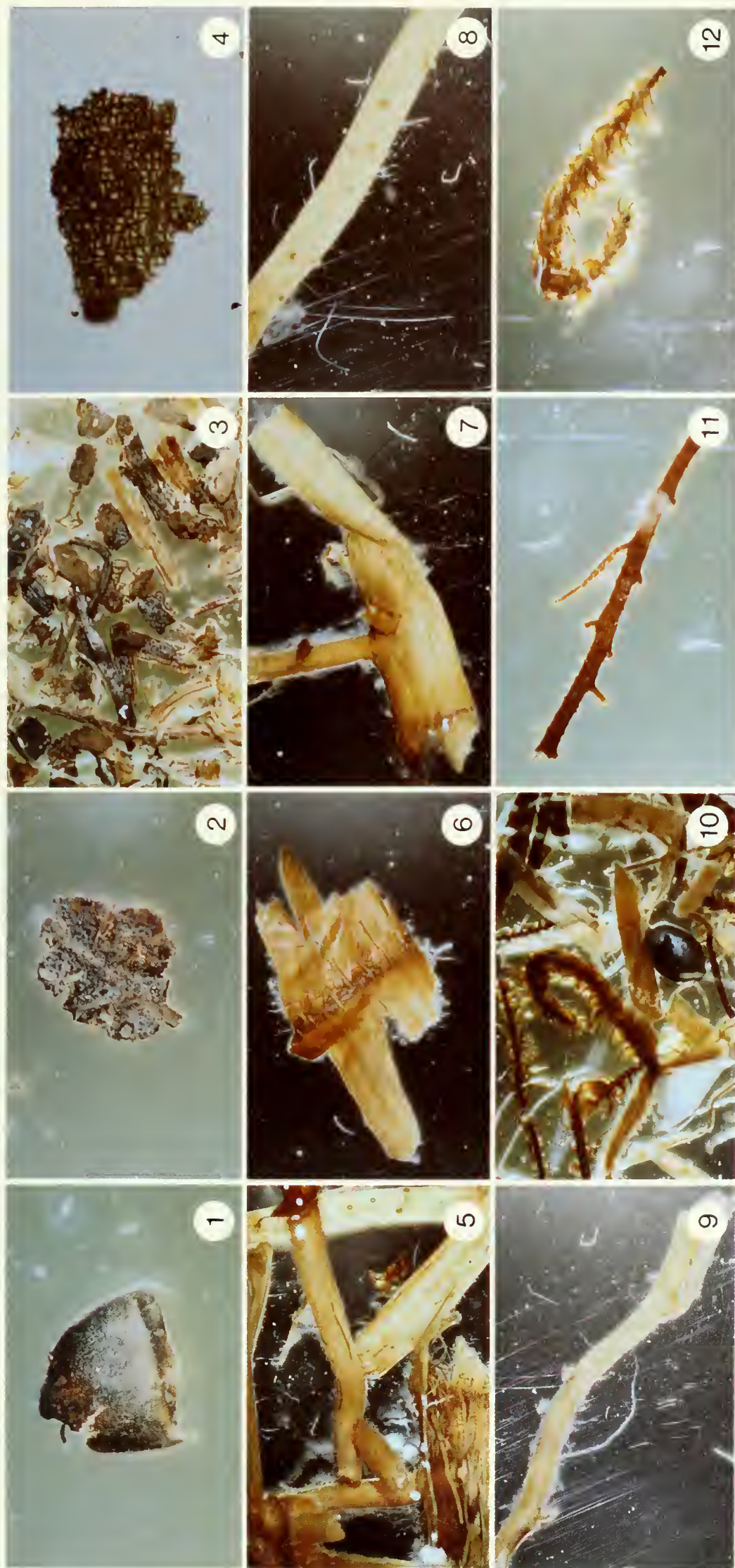


PLATE 21

HERBACAE - LIGNOSAE (LA)

- 21-1 Bud scale of shrubby Lignosae. $\times 18$
- 21-2 Fragment of deciduous leaf. $\times 12$
- 21-3 Fraction 450-1000 μm . Root fragments and tissue remains of Herbaciae; wood fragments, needles, and bark of Lignosae (shrubby Lignosae and *Larix laricina*); a few carbonized pieces of Lignosae. $\times 8$
- 21-4 Fraction of conifer bark (*Larix laricina*). Characteristic cell arrangement. $\times 30$

HERBACAE - MUSCINAE (SH + DP)

- 21-5 Fraction > 2000 μm . Fragments of rhizomes and roots of Herbaciae (Cyperaceae). $\times 5$

- 21-6 Rhizome node of Cyperaceae. $\times 6$
- 21-7 Rhizome of Cyperaceae with node and roots. $\times 5$
- 21-8 Root and secondary root junctions of Cyperaceae. $\times 6$
- 21-9 Root of Herbaciae. $\times 6$
- 21-10 Fraction 1000-2000 μm . Leafy stem of Muscinae; roots and tissue remains of Herbaciae; seed of *Carex cf. trisperma*. $\times 6$
- 21-11 Stem of Muscinae (*Drepanocladus* sp.), with secondary branch and leaf attachment points. $\times 10$
- 21-12 Branch and leaves of *Drepanocladus* sp. $\times 9$



PLATE 22

HERBACAE - MUSCINAE (SH + DP)

- 22-1 Branch and leaves of *Drepanocladus* sp. $\times 10$
- 22-2 Terminal branch of *Sphagnum* sp. $\times 10$
- 22-3 Seed of *Carex trisperma* partially covered by the perigyny. $\times 15$
- 22-4 Seed of *Carex* cf. *trisperma* with parallel sides. $\times 8.0$
- 22-5 Fraction 450-1000 μm . Stems and leafy branches of Muscinae; roots of Herbaceae. $\times 8$
- 22-6 Bud of *Sphagnum* sp., with foliar elements at base. $\times 18$
- 22-7 Leaf of *Drepanocladus* sp., falciform and concave. $\times 20$

- 22-8 Leaf of *Pleurozium schreberi*, costa short, double, and concave with rounded apex. $\times 12$

HERBACAE - MUSCINAE

- 22-9 Fraction $> 2000 \mu\text{m}$. Roots and rhizomes of Herbaceae; leafy stems of Muscinae. $\times 5$
- 22-10 Rhizome with closely spaced nodes and root of Cyperaceae. $\times 5$
- 22-11 Branch and leaves of Muscinae (cf. *Amblystegium* sp.). $\times 8$
- 22-12 Idem $\times 8$



PLATE 23

HERBACAE - MUSCINAE

- 23-1 Rhizome of Cyperaceae. ×8
- 23-2 Rhizome of Herbaceae (*Eriophorum* sp.). ×8
- 23-3 Root system of Herbaceae (*Cyperaceae*). ×9
- 23-4 Fraction 1000-2000 µm. Stems and leaves of Muscinae; roots and tissue remains of Herbaceae. ×8
- 23-5 Branch and leaves of Muscinae (cf. *Amblystegium* sp.). ×5
- 23-6 Fraction 450-1000 µm. Stems and leaves of Muscinae; roots and tissue remains of Herbaceae. ×9

- 23-7 Leaves of Muscinae (cf. *Amblystegium* sp.). Costa flexuous and terminating close to the apex; margin smooth; apex rounded to slightly acuminate. ×7

HERBACAE - MUSCINAE - LIGNOSAE

- 23-8 Fraction > 2000 µm. Rhizomes of Herbaceae; stem fragments of Muscinae and Lignosae. ×5
- 23-9 Rhizome of Cyperaceae with root junction scar. ×5
- 23-10 Rhizome (short) of *Carex* sp., and root attachment point. ×6
- 23-11 Rhizome of Herbaceae. ×6
- 23-12 Stem of Lignosae (cf. *Kalmia* sp.). ×8



PLATE 24

HERBACAE - MUSCINAE - LIGNOSAE

- 24-1 Stem of Muscinæ (type Bryale), with foliar scars and remains. $\times 8$
- 24-2 Fraction 1000-2000 μm . Roots and tissue remains of Herbaceae; stems of Muscinæ (Bryale); fragments of Lignosae xylems. $\times 5$
- 24-3 Stem and branch of Muscinæ (type Bryale), with foliar scars and remains. $\times 9$
- 24-4 Seed of *Scirpus acutus*. $\times 12$
- 24-5 Fraction 450-1000 μm . Roots and tissue remains of Herbaceae; stems of Muscinæ (type Bryale); remains of Lignosae; aggregates of fine material. $\times 6$
- 24-6 Stem of Muscinæ (type Bryale), with foliar scars and remains. $\times 15$

- 24-7 Root of Lignosae (Ericaceae). $\times 5$

MUSCINAE

- 24-8 Subgroup $> 2000 \mu\text{m}$. Stems, branches, and leaves of *Sphagnum* sp.; roots of Ericaceae. $\times 5$
- 24-9 Roots of Ericaceae. $\times 9$
- 24-10 Branch and leaves of *Sphagnum* sp. $\times 6$
- 24-11 Stem of *Sphagnum* sp. covered by hydrocytes; presence of foliar and rameal scars. $\times 9$
- 24-12 Rhizome of Pteridophytae and leaf junction scars. $\times 9$

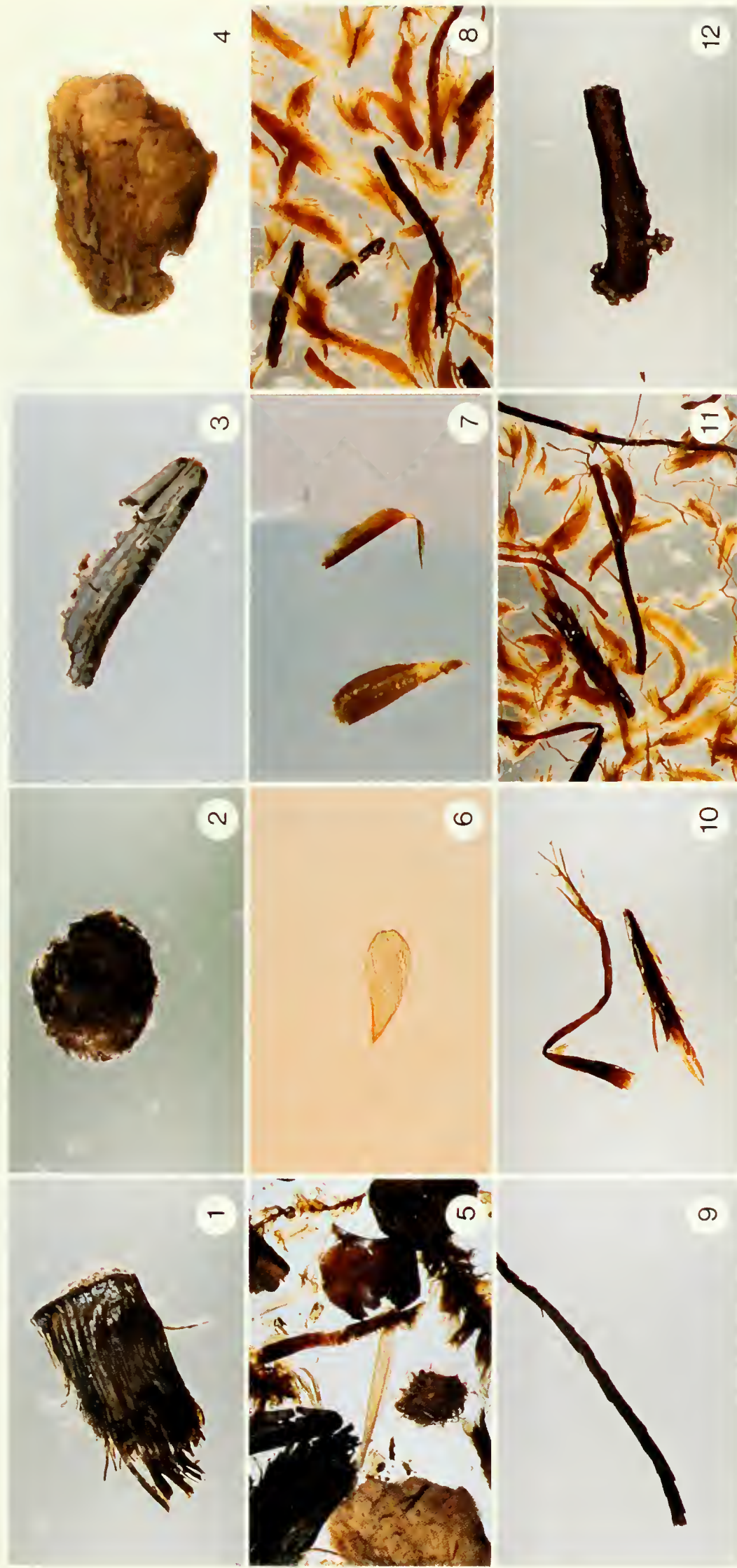


PLATE 25

MUSCINAE

- 25-1 Stem fragment of shrubby Lignosae. $\times 5$
- 25-2 Fraction 1000–2000 μm . Stems of *Polytrichum* sp.; branches and leaves of *Sphagnum* sp.; roots of Ericaceae. $\times 6$
- 25-3 Stems with imbricate leaves of *Polytrichum* sp. $\times 6$
- 25-4 Stem of *Polytrichum* sp., with foliar scars. $\times 10$
- 25-5 Fraction 450–1000 μm . Branches and leaves of *Sphagnum* sp.; fragments of stems and roots of Ericaceae. $\times 8$
- 25-6 Leaves of *Polytrichum* sp., costa broad and thick below the shoulder; leaf lanceolate, beginning at a broad base. $\times 15$
- 25-7 Leaf of *Sphagnum* sp. Cymbifoliate; characteristic cellular arrangement of the leaf. $\times 24$

MUSCINAE – HERBACAE

- 25-8 Fraction $> 2000 \mu\text{m}$. Stems, branches, and leaves of Muscinae; leaves and xylem of Lignosae; fragments of rhizomes and rhizome nodes of Herbaceae. $\times 5$
- 25-9 Xylem fragment of Lignosae. $\times 6$
- 25-10 Leaf of *Andromeda glaucophylla*. Leaf revolute, margin smooth; vascular bundle central and terminating in a rounded apex. $\times 4.0$
- 25-11 Rhizome with closely spaced nodes of Cyperaceae. $\times 6$
- 25-12 Sheathed rhizome of Cyperaceae. $\times 6$

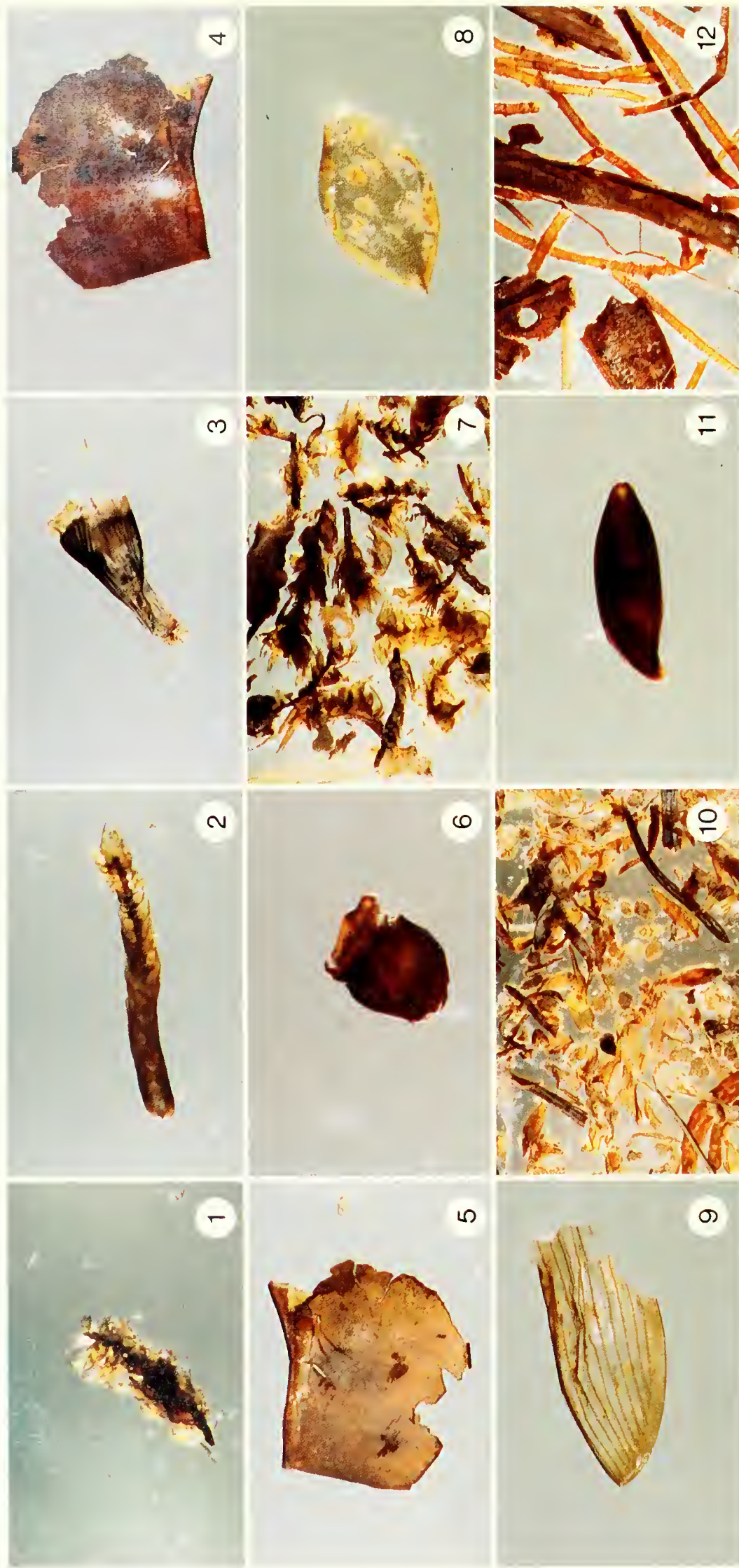


PLATE 26

MUSCINAE - HERBACAE

- 26-1 Branch and leaves of Muscinae (cf. *Scorpidium* sp.) ×6
- 26-2 Branch with imbricate leaves of Muscinae (cf. *Amblystegium* sp.). ×9
- 26-3 Stem base of Cyperaceae. ×9
- 26-4 } Insect mesothorax (exterior face, interior face). ×11
- 26-5 }
- 26-6 Seed of *Cladium mariscoides*. ×6
- 26-7 Fraction 1000-2000 µm. Stems, branches, and leaves of Muscinae (type Bryale). Tissue remains and rhizome fragments of Herbaceae. ×6

- 26-8 Leaf of *Pleurostium schreberi*. ×15

- 26-9 Insect wing. ×15

- 26-10 Fraction 450-1000 µm. Leaves, branches, and buds of Muscinae (type Bryale); needle fragments of Lignosae (conifer); tissue remains and roots of Herbaceae; aggregates of fine material. ×8

- 26-11 Apical bud of Muscinae (type Bryale). ×15

MUSCINAE - LIGNOSAE

- 26-12 Fraction > 2000 µm. Stripped stems, sometimes divided from Muscinae; fragments of stems, roots, bark, and leaves of Lignosae. ×5



PLATE 27

MUSCINAE - LIGNOSAE

- 27-1 Part of a leaf blade of *Chamaedaphne calyculata*, margin slightly dentate. $\times 8$
- 27-2 Part of a leaf blade and petiole of *Chamaedaphne calyculata*. $\times 12$
- 27-3 Stem fragment of *Kalmia angustifolia*, scar around the root junction (?). $\times 8$
- 27-4 Stem fragment of *Sphagnum* sp., without hydrocyte. $\times 19$
- 27-5 Fraction 1000-2000 μm . Stems of Muscinae (*Sphagnum* sp.), and roots of Ericaceae. $\times 6$
- 27-6 Stem of *Sphagnum* sp., foliar scars, attachment sites of branches, and remains of fascicles. $\times 6$

- 27-7 Stem of *Sphagnum* sp., with foliar scars. $\times 6$

- 27-8 Petiole and part of leaf blade of *Chamaedaphne calyculata*; margin slightly dentate. $\times 9$
- 27-9 Stem of *Sphagnum* sp. covered by hydrocyte cells. $\times 9$
- 27-10 Fraction 450-1000 μm . Leaves and branches of *Sphagnum* sp.; leaf and root remains from shrubby Lignosae. $\times 9$

MUSCINAE - HERBACAE - LIGNOSAE

- 27-11 Fraction > 2000 μm . Roots and tissue remains of Herbaceae; roots of Lignosae; stems of Muscinae. $\times 5$
- 27-12 Secondary roots of Herbaceae showing the meristem button. $\times 5$



PLATE 28

MUSCINAE – HERBACAE – LIGNOSAE

- 28-1 Roots of Herbaceae. $\times 6$
- 28-2 Underground stem of shrubby Lignosae. $\times 5$
- 28-3 Underground stem of shrubby Lignosae. $\times 5$
- 28-4 Stem of Lignosae. $\times 9$
- 28-5 Stem of *Sphagnum* sp. covered by hydrocytes. $\times 9$
- 28-6 Fraction 1000–2000 μm . Roots of Lignosae; roots and tissue remains of Herbaceae; leaves and branches of Muscinae (*Sphagnum* sp.). $\times 9$
- 28-7 Fructification of *Chamaedaphne calyculata*. (Note the double verticils of the sepals.) $\times 9$

- 28-8 Part of a leaf blade of Lignosae, spotted by microorganisms. $\times 15$
- 28-9 Part of a leaf blade and petiole of *Chamaedaphne calyculata* (?). $\times 15$
- 28-10 Fraction 450–1000 μm fraction. Leaves and branches of *Sphagnum* sp.; root fragments of Lignosae (Ericaceae). $\times 12$

PTERIDOPHYTAE – LIGNOSAE – HERBACAE

- 28-11 Fraction $> 2000 \mu\text{m}$. Roots and rhizomes of Pteridophytae; fragments of rhizomes and roots of Herbaceae. $\times 6$
- 28-12 Part of a root network of Pteridophytae (*Osmunda* sp.). $\times 6$



PLATE 29

PTERIDOPHYTAE - LIGNOSAE - HERBACAE

- 29-1 Rhizome and root junctions of Pteridophytae. $\times 2.0$
- 29-2 Leaf junction scars on rhizome of Pteridophytae. $\times 8$
- 29-3 Idem
- 29-4 Xylem of shrubby Lignosae. $\times 5$
- 29-5 Rachis of Pteridophytae (presence of white rot). $\times 6$
- 29-6 Wood fragment of Lignosae. $\times 5$

- 29-7 Rhizome with closely spaced nodes of *Carex* sp. $\times 5$
- 29-8 Pubescent root with secondary root junction points of Cyperaceae. $\times 8$
- 29-9 Fraction 1000-2000 μm . Fragments of rhizomes; Herbaceae roots. $\times 8$
- 29-10 Epidermis fragment from the Pteridophytae (presence of white rot). $\times 11$
- 29-11 Rhizome fragment and segment of conductive fascicles of Pteridophytae. $\times 11$
- 29-12 Rhizome of Pteridophytae. $\times 5$

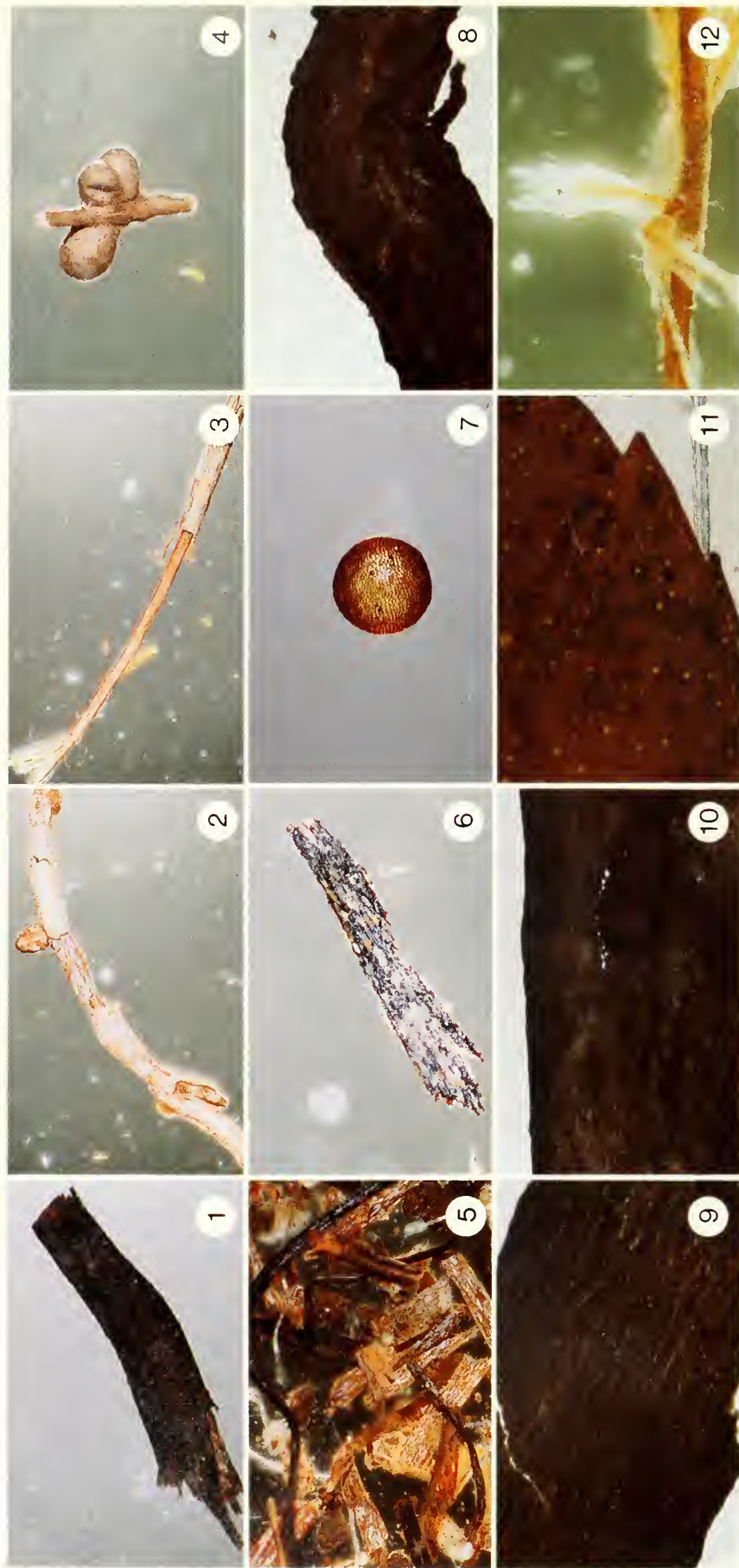


PLATE 30

PTERIDOPHYTAE - LIGNOSAE - HERBACAE

- 30-1 Rachis of Pteridophytæ (close to a rhizome). $\times 9$
- 30-2 Rhizome of Pteridophytæ with root stumps. $\times 16$
- 30-3 Fragment of rachis with epidermis and conductive fascicles of Pteridophytæ. $\times 6$
- 30-4 Mycorrhized root of shrubby Lignosae. $\times 15$
- 30-5 Fraction 450-1000 μm . Fragments of roots and conductive fascicles of Pteridophytæ; fine roots of Herbacae; xylem fragments of Lignosae. $\times 10$
- 30-6 Fragment of rachis of Pteridophytæ (presence of white rot). $\times 18$

- 30-7 Opercule of capsule from *Sphagnum* sp. $\times 18$

COMPLEMENTARY MACROFOSSILS

- 30-8 Underground stem of *Kalmia* sp.; bark covered by broad, deep striations more or less parallel to the axis of the stem. $\times 5$
- 30-9 Underground stem of *Ledum groenlandicum*; bark striated, anastomosed. $\times 5$
- 30-10 Bark of Lignosae (*Vaccinium* sp.?). $\times 9$
- 30-11 Leaf blade of *Myrica gale*; serrated margin at tip of the leaf. $\times 25$
- 30-12 Foliar fascicles on the stem of *Sphagnum* sp. $\times 8$



PLATE 31

COMPLEMENTARY MACROFOSSILS

- | | | | |
|------|---|-------|---|
| 31-1 | Stem of <i>Sphagnum</i> sp. covered by hydrocytes. ×15 | 31-7 | Statoblast of <i>Cristatella mucedo</i> with glochidiolate hairs. ×15 |
| 31-2 | Stem and leaves of Muscinae (<i>Drepanocladus</i> sp.); leaf falciform. ×9 | 31-8 | Stem and leaves of Muscinae (cf. <i>Aulacomnium</i> sp.) ×5 |
| 31-3 | Ephippium of <i>Daphnia</i> sp. ×24 | 31-9 | Collenchymatous fascicles on stem of Gramineae. ×9 |
| 31-4 | Oogonium of <i>Chara</i> sp. ×15 | 31-10 | Spiny leaf of rhizome of <i>Lycopodium</i> sp. ×5 |
| 31-5 | Seed of <i>Potamogeton</i> sp. ×8 | 31-11 | Stem fragment and scaly leaf of <i>Lycopodium</i> sp. ×5 |
| 31-6 | Root of Pteridophytae. ×15 | 31-12 | Sclerotium (<i>Cenococcum geophilum</i>). ×15 |



PLATE 32

COMPLEMENTARY MACROFOSSILS

- | | | | |
|------|--|------|--|
| 32-1 | Underground stem of Ericaceae. X5 | 32-3 | <i>Scheuchzeria palustris</i> (rhizome); sheathing base of rhizome; remains of a root and initial stem bud (?). X1.5 |
| 32-2 | Underground stem of shrubby Lignosae. X5 | 32-4 | <i>Scheuchzeria palustris</i> ; ramified roots covered by absorbent hairs. X1 |
| | | 32-5 | Leaf of Muscinae (type Bryale) (cf. <i>Aulacomnium</i> sp.). X8 |

LIST OF TAXA ILLUSTRATED IN THE GUIDE

(The figures in lightface refer to the macrofossils; those in boldface refer to the reference elements.)

	Elongated structures	Leaves	Seeds	Others
<i>Abies balsamea</i>	4-1			
<i>Alnus rugosa</i>	3-11			
<i>Amblystegium</i> (cf.)	26-2	23-7		22-11, 22-12 23-5
<i>Andromeda glaucophylla</i>	1-2, 1-9	2-9, 2-10, 25-10	6-6	
<i>A. glaucophylla</i>		15-5		
<i>Kalmia polifolia</i>				
<i>Aulacomnium</i> sp.	31-8	32-5		
Bryales	15-11, 24-1			24-3, 24-6, 26-11
<i>Calamagrostis canadensis</i>			10-1	
<i>Calla palustris</i>	8-2, 9-6			
<i>Carex aquatilis</i>			10-7	
<i>C. canescens</i>			10-11	
<i>C. cephalantha</i>			10-8	
<i>C. crinita</i>			11-4, 13-6	
<i>C. exilis</i>			10-9	
<i>C. flava</i>			11-1	
<i>C. gynocrates</i>			11-5	
<i>C. interior</i>			11-7	
<i>C. lasiocarpa</i>	8-4, 9-7		11-6	
<i>C. limosa</i>	9-8		11-3	
<i>C. oligosperma</i>			10-10	9-10
<i>C. pauciflora</i>			11-2	
<i>C. paupercula</i>			10-5	
<i>Carex</i> sp.	8-3, 18-10 18-11, 19-1 29-7		18-3, 18-8	23-10
<i>C. stipata</i>			10-6, 13-6 19-9	
<i>C. stricta</i>	8-5			
<i>C. trisperma</i>			10-12, 17-5 22-3 22-4	
<i>Carex</i> cf. <i>trisperma</i>				31-12
<i>Cenococcum geophilum</i>				4-11, 5-2
<i>Chamaedaphne calyculata</i>	1-1, 1-8 3-9	2-7, 2-8, 14-1, 14-7, 27-1	6-2	27-8, 28-7, 28-9
		27-2		
<i>Chamaedaphne</i> sp.				14-2
<i>Chara</i> sp.				31-4
<i>Cladium mariscoides</i>	7-7, 8-8 8-11		26-6	
<i>Climacium americanum</i>	11-9	11-12		
Conifer	13-3, 16-7			13-5, 20-11
<i>Cristatella mucedo</i>				31-7

LIST OF TAXA ILLUSTRATED IN THE GUIDE (continued)

	Elongated structures	Leaves	Seeds	Others
Cyperaceae	17-12, 18-1 21-6, 21-7 21-8, 23-1 23-3, 25-11			20-1, 22-10 23-9, 23-10 23-11, 25-12 26-3, 29-8 31-3 21-2
<i>Daphnia</i> sp.				
Deciduous				
<i>Dicranum polysetum</i>		12-2		
<i>D. undulatum</i>	11-10	12-3		
<i>Drepanocladus</i> sp.	21-11, 21-12	22-7		31-2
<i>Eleocharis elliptica</i>	7-8, 8-12			
<i>E. palustris</i>			19-8	
<i>Eleocharis</i> sp.			18-4, 18-7	
<i>Equisetum</i> sp.				17-4
Ericaceae	14-5, 20-6, 24-7, 24-9, 32-1			
<i>Eriophorum gracile</i>	7-12, 9-4			
<i>Eriophorum</i> sp.	23-2			
<i>E. spissum</i>	8-7, 8-10		10-3, 15-6	
<i>E. virginicum</i>	8-6		10-4	
Gramineae	19-2			31-9
Herbacae	13-7, 13-8, 14-11, 17-8, 17-10, 17-11, 21-9			19-3, 27-12, 28-1
<i>Hylocomium splendens</i>		12-5, 12-6		
<i>Hypnum linbergii</i>		12-8		
<i>Juncus effusus</i>	7-10, 9-2		10-2	
<i>Juniperus communis</i>		6-1		
<i>J. horizontalis</i>	4-2		7-1	
<i>Kalmia angustifolia</i>	1-3, 27-3	2-11, 2-12, 4-12		
<i>Kalmia</i> cf.	23-12			
<i>Kalmia polifolia</i>	4-10			
<i>Kalmia</i> sp.	30-8	14-3		
<i>Larix laricina</i>	4-3, 4-4	17-3	16-10	16-4, 16-5 16-6, 16-11 20-12, 21-4
<i>Ledum groenlandicum</i>	1-6, 2-4, 3-12, 30-9	3-3, 3-4		
Lignosae	13-2, 16-8, 18-12, 19-7	14-9, 19-6 28-8		19-5, 20-3, 20-8, 24-7, 25-9, 29-6
Lignosae, shrubby	20-4, 20-5, 20-7, 20-9			21-1, 25-1, 29-4, 30-4, 28-2, 28-3, 28-4, 32-2
<i>Lycopodium</i> sp.		31-10, 31-11		
<i>Menyanthes trifoliata</i>	8-9		9-11	
<i>Mnium affine</i>		12-1		
<i>Myrica gale</i>	1-5, 2-2, 2-3	3-2, 5-1, 5-3, 30-11	6-7	3-10

LIST OF TAXA ILLUSTRATED IN THE GUIDE (concluded)

	Elongated structures	Leaves	Seeds	Others
<i>Nemopanthus mucronata</i>	2-6, 4-7		6-10	
<i>Osmunda</i> sp.				28-12
<i>Picea glauca</i>		5-9, 5-10	7-3	
<i>P. mariana</i>	19-11	5-6, 5-12, 15-2	6-8	
<i>Pinus banksiana</i>			7-5	
<i>P. divaricata</i>		5-8		
<i>P. resinosa</i>			7-4	
<i>P. strobus</i>		5-11	6-11	
<i>Pleurozium schreberi</i>	11-11	12-11, 15-7, 15-8, 22-8, 26-8		
<i>Polygonum lapathifolium</i>			11-8	
Polypodiaceae				17-6
<i>Polytrichum</i> sp.	25-4	12-7, 25-6		25-3
<i>Potamogeton</i> sp.			31-5	
<i>Potentilla palustris</i>	5-4, 5-5		6-9	
Pteridophytae	29-1, 29-12, 30-3, 30-6			24-12, 29-2, 29-3, 29-5, 29-10, 29-11, 30-1, 30-2, 31-6
Pteridophytae/ <i>Equisetum</i> sp.	17-2			
<i>Ptilium crista-castensis</i>	12-4			
<i>Rhododendron canadensis</i>	4-8, 4-9			
<i>Rhynchospora alba</i>			9-12	
<i>Salix</i> sp.			16-12	
<i>Scheuchzeria palustris</i>	7-11, 9-3, 32-3, 32-4	9-9		
<i>Scirpus acutus</i> / <i>S. validus</i>	7-9, 9-1		24-4	
<i>Scorpidium</i> sp.				26-1
<i>Sphagnum</i> sp.	12-9, 14-8, 15-3, 15-9, 15-10, 15-12, 30-12, 31-1	15-1, 25-7		22-2, 22-6, 24-10, 27-4, 27-6, 27-7, 27-9, 28-5, 30-7
<i>Taxus canadensis</i>		5-7	7-2	
<i>Thuja occidentalis</i>	4-5, 4-6		7-6	
<i>Tomenthypnum nitens</i>		12-10		
<i>Tsuga canadensis</i>			6-12	
<i>Typha</i> sp.	8-1, 9-5			
<i>Vaccinium angustifolium</i>	1-4, 1-10, 1-11, 1-12, 2-1	3-1		
<i>V. macrocarpon</i>	2-5	3-7, 3-8		
<i>V. myrtilloides</i>			6-4	
<i>V. oxycoccos</i>	1-7, 2-5	3-5, 3-6	6-3	
<i>Vaccinium</i> sp.	13-11, 13-12, 30-10			
<i>V. uliginosum</i>			6-5	

